The Boundary Cases for the P4P rates

Smart Energy Services to Improve the Energy Efficiency of the European Building Stock

Deliverable nº:	**D4.3**
Deliverable name:	**The Boundary Cases for the P4P rates**
Version:	**1.9**
Release date:	**11/12/2020**
Dissemination level:	**Final deliverable public**
Status:	**Submitted**
Authors:	Arturo Lapietra OMNIA ENERGIA, Vincenzo D'Agostino OMNIA ENERGIA, Benedetto Grillone CIMNE
Contributions:	**Project partners:** Institute for European Energy and Climate Policy Stichting (IEECP), Centre Internacional de Metodes Numerics en Enginyeria (CIMNE), Geco ltd ab oy (GECO), Università della Calabria (UNICAL). **Interviewees:** Luigi Rizzo, Regina Drazhi, Massimiliano Mazzeo, Emilio D'Agostino (Automation Engineering Innovation – AEI), Francesco Guzzo Cava – FGC Ingegneria (ITALIA),Giuseppe Spagna – Studio Tecnico Giuseppe Spagna (ITALIA), Michele Liziero - Energy Team SpA, Nicola Sorrentino – DIMES UNICAL (ITALY)

This report aims at devising classes of EEMS according to the value of their energy savings for energy providers and at estimating the P4Prates energy providers would be willing to offer. This Deliverable includes the stakeholder consultation process to present our methodology to relevant stakeholders and collects feedback on cases and scenarios that validates our results.

Results include a detailed classification and evaluation of the EEMs (Please refer to the attached and linked spreadsheet file: SENSEI D4.3 Appendix A: classes of EEMs.xls) and an estimation of P4P rates that energy providers would be willing to offer according to the classification of EEMs.

Document history:

Version	Date of issue	Content and changes	Edited by
1.0	23/05/2020	First draft version	Omnia Energia
1.1	01/06/2020	Review	CIMNE
1.2	01/06/2020	Review	IEECP
1.3	01/06/2020	Second draft version – Classification of EEMs	Omnia Energia
1.4	31/08/2020	Third draft version – SH consultation Process	Omnia Energia
1.5	18/09/2020	Review	CIMNE
1.6	22/09/2020	Fourth draft version – P4P rates	Omnia Energia
1.7	20/11/2020	Receiving other comments by partners	IEECP, HEBES, F4, Gencat
1.8	28/11/2020	Final draft	Omnia Energia
1.9	11/12/2020	Ready for submission	Omnia Energia

Peer reviewed by:

Partner	Reviewer
CIMNE	Benedetto Grillone
FACTOR 4	Charles-Henri Bourgois
GENCAT	Monica Pascual
HEBES	Sophia Theodoropoulou
HEBES	Sotiris Papadelis
IEECP	Filippos Anagnostopoulos
IEECP	Dimitra Tzani

Deliverable beneficiaries:

WP / Task
WP2 / T2.2 Establish and engage with the SENSEI stakeholder community
WP5 / T5.2 Derive P4P arrangements that align the interests of all involved parties
WP6 / T6.1: Ex-ante evaluation of the financial benefits for the investors

Table of contents

Abbreviations and Acronyms

Acronym	Description
BACS	Building Automation And Control System
CE4ALL	Clean Energy For All Europeans
CHP	Combined Heat And Power
CIMNE	Centre Internacional De Metodes Numerics En Enginyeria
CO_2	Carbon Dioxide
DHW	Domestic Hot Water
DRIPE	Demand Reduction Induced Price Effects
DSO	Distribution System Operator
EE	Energy Efficiency
EEM	Energy Efficiency Measure
EEO	Energy Efficiency Obligation
EEOS	Energy Efficiency Obligation Scheme
EN	European Standards
ENSPOL	Energy Saving Policies And Energy Efficiency Obligation Schemes
EPC	Energy Performance Contract
ESCo	Energy Service Company
EU	European Union
IEC	International Electrotechnical Commission
IOT	Internet Of Things
LED	Light Emitting Diode
NREL	National Laboratory Of The U.S. Department Of Energy, Office Of Energy Efficiency And Renewable Energy, Operated By The Alliance For Sustainable Energy,
P4P	Pay For Performance
PG&E	Pacific Gas & Electric Company
RES-E	Renewable Energy Sources For Electricity
SENSEI	Smart Energy Services To Improve The Energy Efficiency Of The European Building Stock
TOE	Tonne Of Oil Equivalent
TSO	Transmission System Operator
U.S.A.	Unites States Of America

Acronym	Description
WP4	Work Package 4 Of SENSEI

Executive Summary

Pay-for-performance (P4P) energy efficiency programmes aim to deliver greater than the classic non-performance based programmes (like most EEO schemes) and more persistent energy savings by compensating (paying) energy efficiency resources based on a comparison of metered energy consumption and modelled counterfactual energy consumption.

Energy savings are used as the indicator to measure the energy efficiency project's performance, and payments are done on an ongoing basis "as the savings occur" (Szinai et al., 2017).

Payments are channelled from an organisation which is willing to pay to support energy savings, usually a public authority or a utility (or other entities) to EE projects.

In this report, we examined the range of the P4P rates that energy providers would be willing to offer for energy savings (and not only) according to the different drivers for energy efficiency monetization.

Various definition of the *P4P rate concept has been devised, but it could be simply interpreted as a numerical value (€/kWh) that energy providers would be willing to pay for each kWh saved or moved to another time of the day.* These rates could vary according to the electricity demand curve (a kWh saved at peak time is worth more than one saved at night/in the valleys).

Some P4P schemes implemented outside the EU [1] provide an upfront, non-performance-based incentive in addition to performance-based payments. This approach helps participants to manage cash flows and financial risks. Such a method is also proposed in this study, considering that energy providers or energy companies (as Tso and DSO, are the identified entities paying for providing an upfront incentive through rollout of energy efficiency interventions

The proposed approach is not focused on quantifying the P4P rates, but on identifying which variables and parameters affect these rates. To this end one the first purpose of this report is to devise classes of EEMs according to the value of their energy savings for energy providers and estimate the P4P rates that energy providers would be willing to offer according to the different drivers for energy efficiency monetization. A concrete classification and evaluation of the Energy Efficiency Measures (EEMs) is the basic step to this end.

We will use the acronym EEMs to refer to both:

(a) measures that decrease energy consumption, and

[111] Santini M. , Tzani D,, Thomas S. , Stavrakas, V., Rosenow J., Celestino A. (2020): Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency, Deliverable 4.4 SENSEI 2020

(b) the deployment of solutions for on-site generation of RES-E and/or of renewables-based or renewables-compatible (like heat pumps) solutions for heating and cooling.

The Classes of EEMs have been contextualized for different sectors: industrial commercial and residential.

To date, most of the P4P programmes outside the EU have been implemented in the commercial and industrial sectors. We provided also a residential classification of the EEMs because with the deployment of smart meters the procedure for collecting data becomes less complicated and the cost of whole-building measurement decreases, making M&V for P4P more practical for sectors such as residential buildings and SMEs[2].

In this report, different measures that affect the daily consumption profile have been identified and are presented below:

- Measures that reduce the use of electricity without affecting its temporal profile.
- Measures that allow improved control of electricity consumption.
- Measures that affect both the electricity used and the hours required to perform a task.
- Measures that increase electricity consumption due to fuel substitution.
- Measures that install technology for the generation of electricity onsite. In the EU, we are moving away from the feed-in tariff system and towards supporting self-consumption.

Overall, seven different categories of EEMs were identified in the carried-out analysis and, the specific interventions belonging to each of these classes are specified in detail in the following chapters:

1. Distributed Generation
2. Storage
3. Conversion of the Energy Carrier
4. Building Intervention
5. Heating Ventilation Air Conditioning and Domestic Hot Water Systems

[2] Santini M. , Tzani D,, Thomas S. , Stavrakas, V., Rosenow J., Celestino A. (2020): Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency, Deliverable 4.4 SENSEI 2020

6. Electrical Systems

7. Building &Automation Control Systems

We structured four different tables for evaluating the EEMs:

1. Table A: Grid effects.
2. Table B: Building benefits.
3. Table C: Value of measures.

In particular, **Table A** contains a qualitative analysis of the effects on the grid; **Table B** explains a technical qualitative analysis with details of users' benefits; **Table C** shows a quantitative analysis. At the end of each analysis (evaluation) a class of "goodness" is calculated for each EEM, from the higher value to the lower (please see **Errore. L'origine riferimento non è stata trovata.**).

Class (Value)	Class (Alphabetical)
10	A
9	B
8	C
7	D
6	E
5	F
4	G
3	H
2	I
1	J

Table 1 - Mapping the class of the EEMs with the corresponding numerical value

The classes obtained for each of the aforementioned tables (A, B, and C) are then integrated in a final class of goodness denominated **Table X** (if no letters is joined to the ID, it means that the classification is the same for all sectors residential-Industrial-commercial):

Legend	
Res	Residential
Ind	Industrial
Com	Commercial

EEMs name	EEM ID	Class
Photovoltaics	1 Res	D
	1 Ind	C
	1 Com	C
Wind	2 Ind	B
Solar collectors	3 Res	E
	3 Com	D
Cogeneration	4 Res	G
	4 Ind	C
	4 Com	C
trigeneration	5 Ind	D
	5 Com	D
Batteries	6 Res	H
	6 Ind	G
	6 Com	G
Hydroelectric	7 Ind	C
CAES	8 Ind	C
Hydrogen	9 Ind	F
	9 Com	F
Thermal storage	10 Res	E
	10 Ind	D
	10 Com	D
Refrigerator storage	11 Ind	E
	11 Com	E
Heat pump	12 Res	B
	12 Ind	B
	12 Com	B
Electric vehicles	13 Ind	F
Thermal coat	14 Res	C
	14 Ind	B
	14 Com	B
Fixtures	15 Res	G
	15 Ind	H
	15 Com	G
Solar screens	16 Res	D

	16 Ind	D
	16 Com	C
District heating	17	G
Heat recovery	18 Com	E
Heat pump	19 Res	E
	19 Ind	C
	19 Com	C
Diffusers	20 Res	F
	20 Ind	C
	20 Com	B
Hydronic appliances	21 Res	C
	21 Com	A
DHW recovery	22 Res	F
	22 Com	D
Circulators	23 Res	H
	23 Com	D
Fans	24 Ind	E
	24 Com	B
LED	25 Res	B
	25 Ind	B
	25 Com	B
Efficient electric motors	26 Ind	C
	26 Com	B
Capacitor bank	27 Ind	E
	27 Com	D
Optimizers	28 Res	D
	28 Ind	B
	28 Com	B
Heating	29	E
Domestic hot water	30	F
Cooling	31	E
Ventilation and Conditioning	32	B
Lighting	33	F
Solar screens	34	F
TBM systems	35	F

Table 2 - Classes of EEMs for Table X

The best intervention according to this classification procedure appears to be the conversion of heating from fuel boilers to electric heat pumps. The thermal coat has also proved to be very advantageous while fixtures and sunscreens give poorer results. Subsequently, the intermediate positions are occupied by distributed production plants and interventions on the electrical system. Storage and BACS have poor results, while the heating system is the most articulated one offering advantageous and disadvantageous interventions.

The histograms below show the classes of EEMs in terms of numerical values (in descending order) for the residential sector:

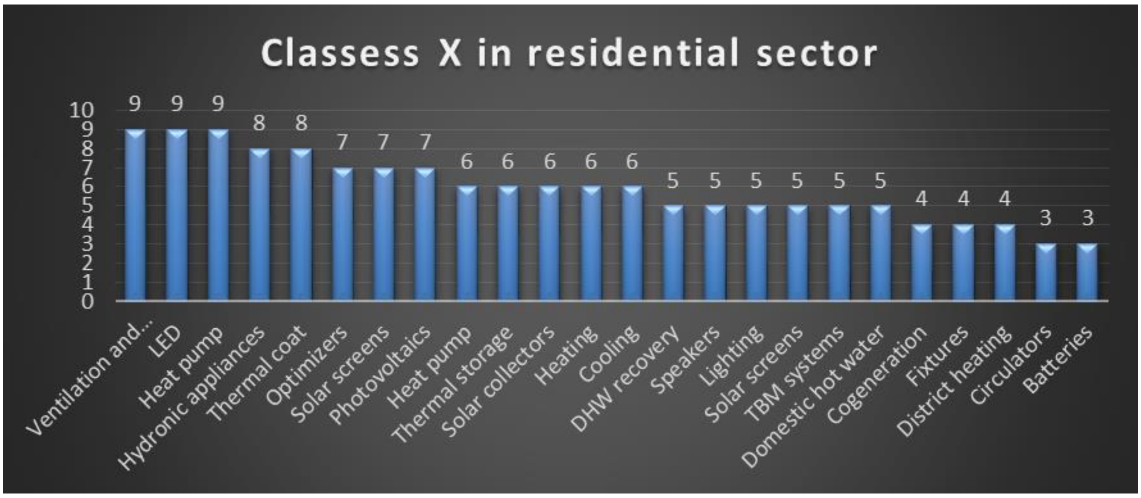


Figure 1 - Classification obtained according to Table X for the most significant EEMs in Residential sector

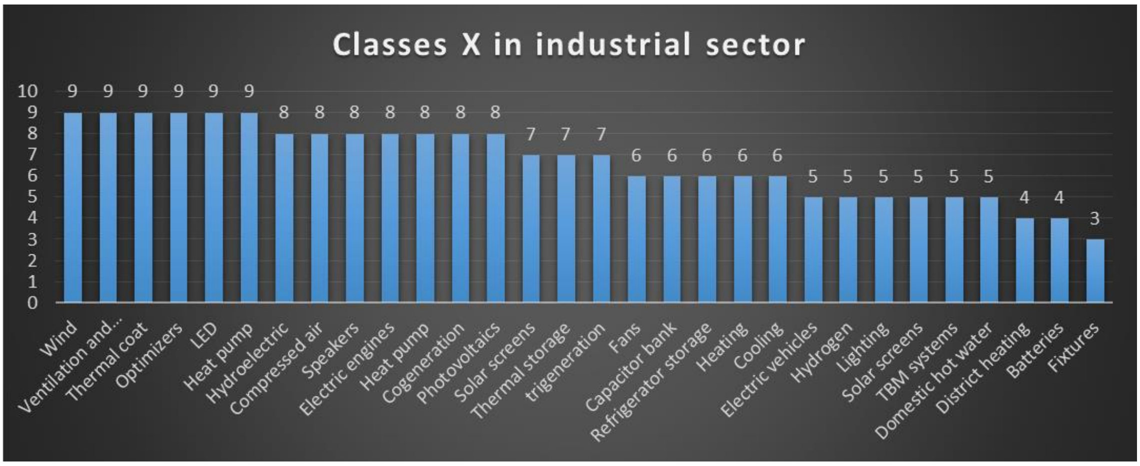


Figure 2 - Classification obtained according to Table X for the most significant EEMs in industrial sector

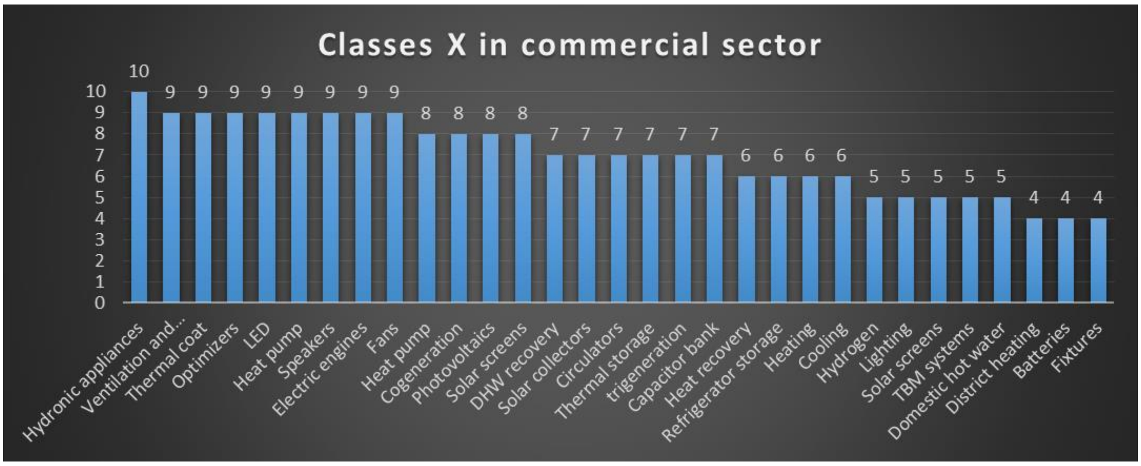


Figure 3 - Classification obtained according to Table X for the most significant EEMs in Commercial sector

The approach followed for the determination of the classes is described in this report, however for further details on the numerical calculations please refer to the attached and linked spreadsheet file: SENSEI D4.3 Appendix A: classes of EEMs.xls **which is an integral part of the deliverable itself.** *Appendix A* section helps for understanding the structure of excel file.

After devising the classes of EEMs the P4P rate concept is devised through the mechanism of the Energy Efficiency obligation schemes and considering the energy provider, as TSOs and DSOs, perspectives. The basic idea behind the proposed approach is that the energy providers could set a higher value for P4P rates the greater is the class of the EEMs.

These entities could be willing to offer a P4P rate in the SENSEI value chain based on their proper needs and their development plans.

In particular, we supposed that Distribution System Operators (DSOs), as obliged parties in the EEOS mechanism (the others obliged parties under EED Article 7 are the energy suppliers the retailers), could deliver the energy savings target, by providing energy efficiency measures directly to customers, on large scale.

On the TSO side, the transition of the electricity system towards complete decarbonisation requires the full integration of EEMs in order to reduce emissions on a long-term basis, while avoiding the need for costly capacity, lowering carbon emissions avoiding or deferring the need for costly network upgrades and allowing heating and cooling system to be used more flexibly.

Therefore, SENSEI project through the role of the aggregator could turn to the TSO to receive an incentive following the implementation of energy efficiency interventions bringing overall benefits to the grid.

Associating these benefits with consistent returns and stable long-term cash flows could result in making energy efficiency more attractive to investors.

1 Introduction

Buildings account for 40 percent of the EU's final energy consumption[3], and, as a result, energy efficiency in buildings has been identified by the European Commission as a very real and major opportunity:

- Energy efficiency decreases the total amount of primary energy used, which, in turn, reduces CO_2 emissions.
- Reduction of energy consumption favours the transition to clean energy, because it reduces the need for investments and finding sites for the deployment of RES technology.
- Energy efficiency can reduce EU energy import dependency, create growth and employment, reduce fuel poverty, and result in more comfortable and healthier buildings.

Despite its potential, the current building renovation rate in EU is very low (0.4-1.2% per year depending on the country)[4] in particular due to the lacking of private investments. For energy efficiency to be attractive to investors, it must be associated with consistent returns and stable long-term cash flows.

In this challenging context, the SENSEI project proposes a Pay-for-Performance (P4P) business model in the EU, which offers an effective way to **engage both energy providers and third-party investors in energy efficiency**. The idea behind a P4P scheme for financing an energy retrofit project is that the financial flows between the involved parties are linked to the actual/metered and weather-normalized energy savings produced by the project. Payments are channelled from an **organisation which is willing to pay to support energy savings** (usually a public authority or a utility) to projects. To date, P4P programmes targeting buildings have mostly been run by utilities that are subject to energy efficiency resource standards (commonly known as Energy Efficiency Obligation Schemes in the EU), but more applications could be envisioned (capacity mechanism for example).

The concept of agreeing on a price for the delivery of energy savings is not new (e.g. Standard offer programmes, Demand-side management bidding programmes, energy efficiency feed-in-

[3] https://ec.europa.eu/info/news/new-rules-greener-and-smarter-buildings-will-increase-quality-life-all-europeans-2019-apr-15_en

[4] https://ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf

tariff) but in the SENSEI vision the incentives may be coming from the energy provider side too. From the analysis of P4P scheme outside the EU (D4.4 Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency, 2020 SENSEI), public authority, utilities and energy companies are in charge of channelling the payments to the entity which is tasked with delivering the performance.

In the context above explained, **detailed knowledge of the energy efficiency measures** is essential, not only in terms of generated energy savings but also in terms of grid needs and building or usage characteristics. For this reason, considering the value that the implemented measures bring to the overall energy system it is a very crucial point when dealing with P4P schemes.

This report identifies and where possible quantifies the market value of energy savings from the energy providers' perspective (analysing the details of P4P schemes that compensate energy efficiency as an energy resource).

This report identifies the P4P rates energy providers would be willing to offer after devising classes of EEMs. The P4P rates are estimated from the energy provider's perspective considering energy efficiency obligations and different market conditions.

The methodology of classification and evaluation takes into consideration relevant technical, financial and, other (e.g. comfort, innovation, duration, etc.) parameters from the view of end-users, energy providers, investors and ESCOs.

The main goal is to identify the different characteristics of an energy efficiency intervention highlighting the value that it brings to the overall energy system considering energy efficiency as an energy resource and quantifying the market value of energy savings from the energy providers' perspective.

Methodology overview

As pre-announced above, the first step was related to the definition of an evaluation scheme for energy savings of different EEMs (classes of EEMs). The question is **which of these measures (and when) are most appropriate for a P4P scheme.** We analyzed a lot of EEMs focusing on a subset with the higher evaluation class. This allowed us to better explore all the other parameters that define the value of these measures, such as grid needs and building or usage characteristics. For this reason, qualitative and quantitative analysis have been performed before proceeding with the EEMs classification.

One of the main objectives of this study is to translate consumption changes into specific energy efficiency measures.

After devising the classes of EEMs the **P4P rate** concept is presented through the mechanism of the Energy Efficiency obligation schemes and considering the energy provider (TSOs and DSOs) perspective. These entities, distribution companies and energy providers, could be willing to offer incentives for EEMs bringing long-term impacts (e.g., energy consumption savings, stability resilience, security off the grid, etc.) on the entire energy system. An energy provider could set a higher value for P4P rates the greater is the class of the EEMs.

Associating the general benefits of an EEM plan with consistent returns and stable long-term cash flows could result in making energy efficiency more attractive to private investors.

Furthermore, the present report outlines the stakeholder consultation process and presents the proposed methodology to relevant stakeholders by collecting feedback that can validate our results and promote the new concept and definition of P4P rates.

Regarding the viability of the P4P pilots, the experience from the USA suggests that new ideas and solutions are necessary to allow P4P to be relevant for EEMs that require a switch from an unmetered fuel to electricity: for this reason, the EEM category "conversion of the energy fuel" is analysed. P4P schemes focus also on permanently reducing power consumption, especially at peak times. Since the value of the energy saved is time-dependent, the provided EEMs classification identifies the opportunities for efficiency valorisation according to their impact at different times of the day and particularly during peak consumption time.
Considering the successful examples in the U.S.A. there is considerable scope for allowing energy efficiency to bid into capacity markets in the EU. We should also expect **new opportunities for the valorisation of energy efficiency** by mitigating the need for ramping reserves to address the "duck curve" effect. Assuming that energy providers are both willing and able to take energy efficiency to the markets that can monetize it, P4P schemes can act as the vehicle for compensating energy efficiency as an energy resource.
On the other hand, investors seek business models that allow energy efficiency improvements to become a commodity that can be shared and/or exchanged. If an investor provides the capital for an energy efficiency retrofit, this investor should have a share on the building's value. Then, the quantification of the actual monetary value of the achieved energy savings can allow the investor to claim this value. As long as it is feasible to **quantify the monetary value of the energy savings**, we can use P4P schemes to distribute this value accordingly. The energy provider could integrate the monetary value..

Building on earlier successful experimentation outside of the EU, the evaluation of P4P rates will support the SENSEI model designing concepts: a business model will help to enable the compensation of energy efficiency as an energy resource and aggregate buildings and energy efficiency measure plans into portfolios of energy savings that can be offered to energy providers and to third party investors through energy savings purchase agreements.

The report is structured as follows:

Section 2 proposes an analytical approach for the EEMs classes definition

Which EEMs and when are more appropriate for a P4P scheme?

Classification of the EEMs according to the value of their energy savings for energy providers

Qualitative and quantitative analysis of the EEMs

Classes definition

Section 3 goes forward to the Stakeholder Consultation and engagement process to validate the initial results

Stakeholders Identification and invitation to the SENSEI community

The methodological choices and the approach: in-person focus groups and interviews by mail.

Collecting feedbacks and validation of results

Section 4 Evaluates the EEMs classification schemes and estimates the P4P rates that energy providers would be willing to offer

Inside the concepts of Energy Provider and P4Prates

The P4P rates in the mechanism of Energy Efficiency Obligation schemes

The P4P rates from the Energy Provider (TSO) perspective

---

2 Devising the classes of EEMs

Section 2 aims at devising the classes of Energy Efficiency Measures (EEMs) through a thorough analysis and an iterative approach. In the course of this report, the acronym EEMs is used to refer to both:

a) measures that decrease energy consumption;

b) deployment of solutions for on-site generation of RES-E and/or of renewables-based or renewables-compatible (like heat pumps) solutions for heating and cooling.

Section 2.1 explains the crucial points for devising a list of EEMs suitable for P4P scheme considering the different ways in which an energy efficiency intervention can affect the load profile. **Section 2.2** proposes EEMs categorization. **Section 2.3** summarizes EEMs classes according to their energy savings value and the effect of all technical and financial parameters which characterize each of them.

2.1 Starting points to create a list of relevant EEMs

The list of energy efficiency measures is based on the NREL's building component library[5], Building Sync Standard [6]. The list has been defined using knowledge and expertise in the field of energy efficiency intervention. A verification of the list was then conducted in line with the contents of a SHERPA database. The database was created in the framework of the Interreg MED project SHERPA [7]and of the Horizon 2020 project EDI_Net[8]

The SHERPA database is intended to be a repository where to store the information of energy efficiency measures implemented in different buildings of an organization. Its objective is to facilitate the monitoring and evaluation of the implemented measures and encourage the exchange of experiences amongst the different users. The four main functional requirements of the SHERPA database are:

- track energy performance in detail,

[5]https://bcl.nrel.gov/nrel/types/measure

[6]https://buildingsync.net/schema/v1.0/datadictionary/

[7] https://sherpa.interreg-med.eu/

[8] https://edi-net.eu/en/home.html

- communicate energy performance in a user-friendly manner,
- facilitate communication between stakeholders,
- manage an intervention plan for energy efficiency.

The core of SHERPA is the analysis of smart meter data from buildings, renewable energy systems, and building energy management systems (BEMS) using Big Data analytics technologies. The architecture of the application is based on two big interfaces. The first interface is defined as the SHERPA App and contains the user and the communication interfaces. The second interface is the Big Data Engine, which contains the distributed storage database and the data analytics software modules. The main function of the SHERPA App is to allow the interaction between the end-users (building managers) and the Big Data Engine. It consequently facilitates the settings editing, the data importing and the visualization of results.

Application example on SHERPA Database

The features and the interface of the SHERPA database are briefly presented.

The general dashboard of SHERPA allows users to access a list of all the buildings that they are managing. As presented in Figure 4, it is possible to order the list of buildings according to the consumption, the efficiency, or the number of energy efficiency measures applied.

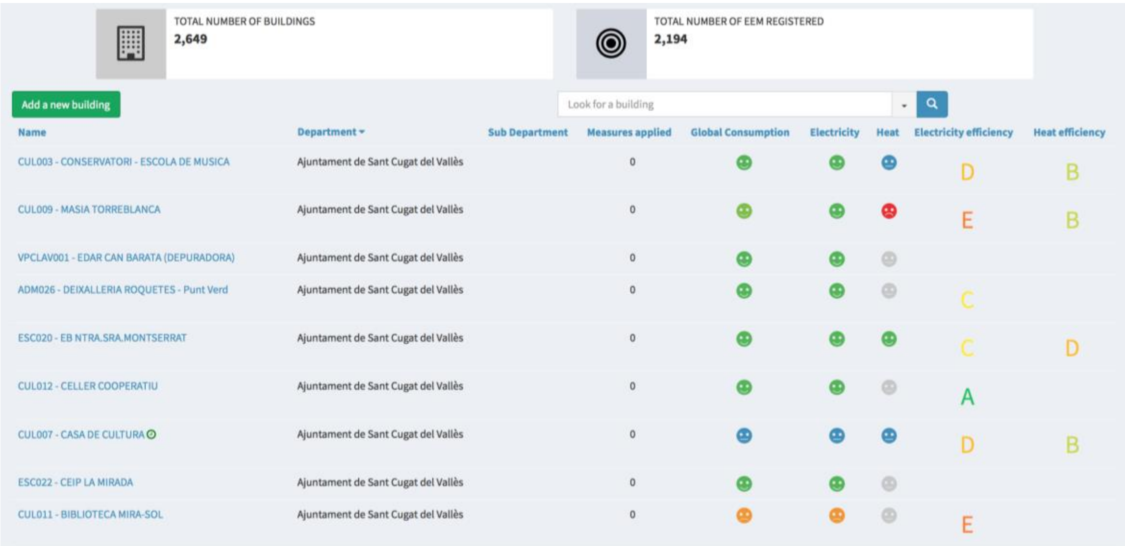


Figure 4 The Sherpa General Dashboard

By clicking on a specific building, the building dashboard can be accessed. In the building dashboard, the user can view a summary of the registered energy efficiency measures, the total investment, and the total electricity and heat consumption and savings.

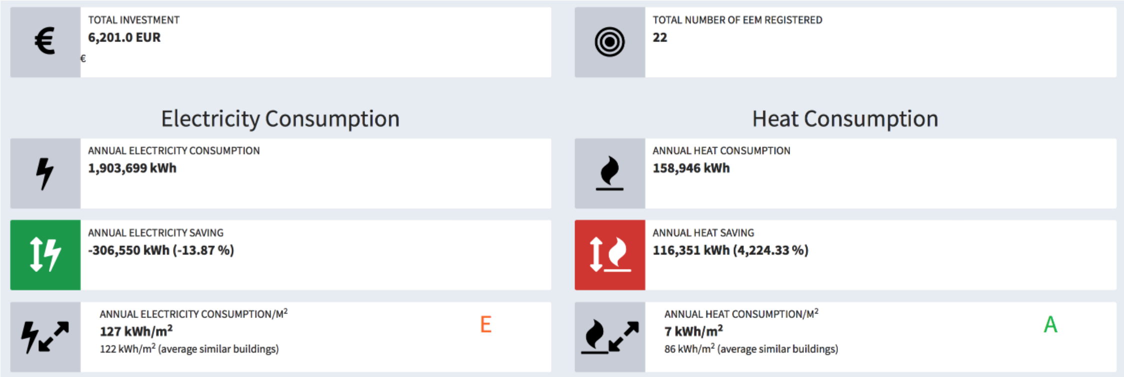


Figure 5 - The SHERPA building dashboard

On the same page, the user can access graphs representing the trend of electricity and heat consumption for the last year. Two lines are plotted: the baseline (predicted) consumption and the actual consumption.

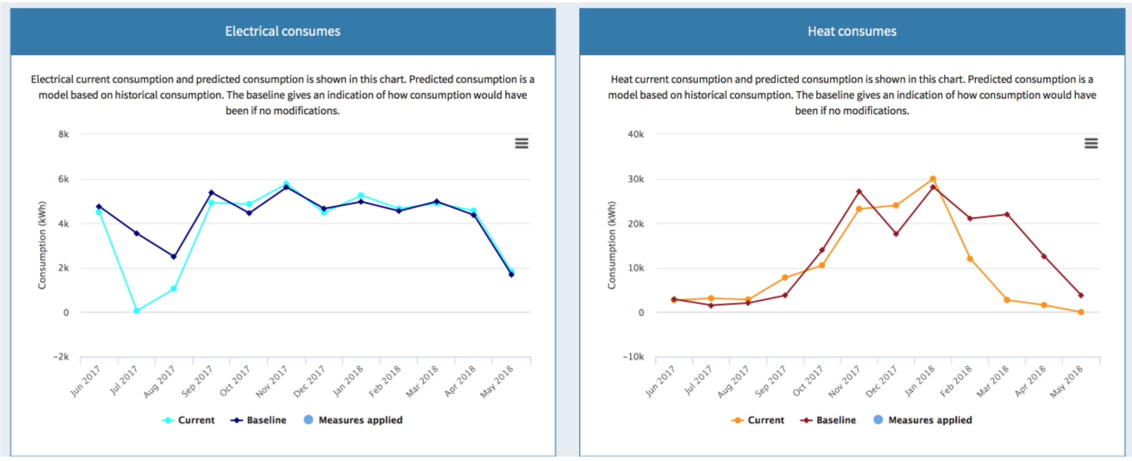


Figure 6 - Actual and predicted consumption graphs in the SHERPA platform

Finally, users can access electricity and heat consumption comparisons between the selected building and similar buildings. If further information concerning the total area of the building is added, the user can decide to visualize on the graphs either the absolute values or the surface normalized values. The graph will show how the selected building is performing compared to other similar buildings and to the most efficient buildings of the same typology, as well as a letter representing the efficiency of the building (kWh/m^2y).

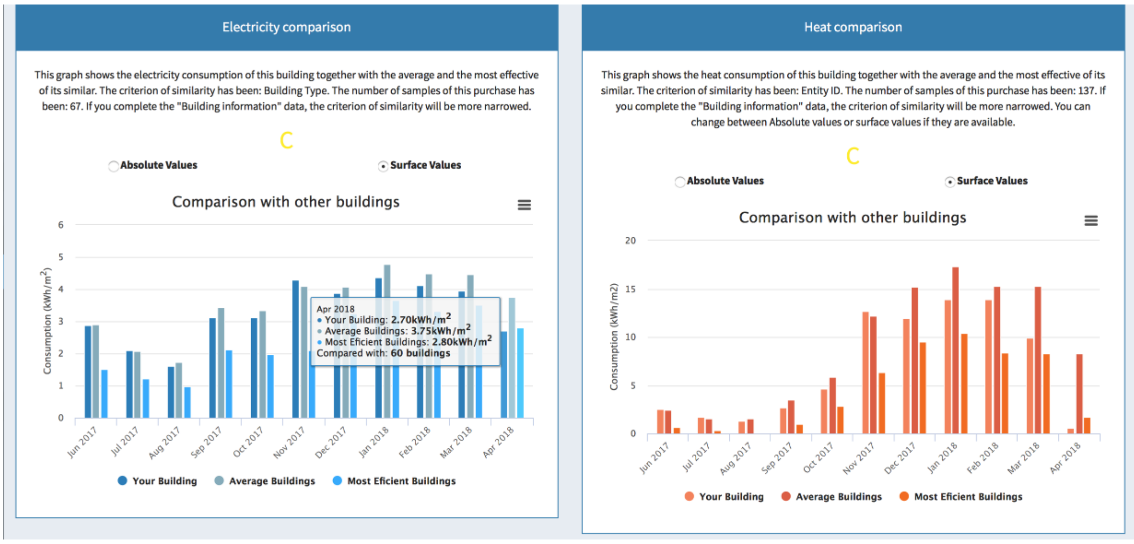


Figure 7 - Building energy performance comparison in the SHERPA platform

2.1.1 Classification of the energy efficiency measures

Residential buildings dating between 1945 and 1980 are the major culprits as they have the highest energy consumption. As a result of the recent economic crisis, funds have been lacking to renovate these energy-sapping structures. However, to reach the EU's energy efficiency targets, this situation needs to be addressed quickly. It is important to have a long-term strategy when renovating national building stocks. While legislation exists to improve energy performance in new constructions, there is currently none for the energy efficiency renovation of existing buildings. This is the situation in terms of legislation, but from a technical point of view, each energy efficiency measure has different repercussions on the electricity network.

Following this technical aspect, five different ways in which an energy efficiency intervention can modify the load profile have been defined:

- Measures that reduce the use of electricity without affecting its temporal profile. EEMs that reduce the electricity required to accomplish a specific end-use Task;
- Measures for improved control of electricity consumption. The energy consumption changes result from modifying the controlled equipment's duty cycle (i.e., changing the hours of operation);
- Measures that affect both the electricity used and the hours required to perform a task. For example, converting electric resistance water heaters to heat pump water heaters, or electric resistance heating to ductless heat pumps, will produce savings that are shaped differently than the underlying end-use load shape;

- Measures that increase electricity consumption due to fuel substitution: an old gas-or oil-fuelled boiler may be replaced by a heat pump;
- Measures that install technology for the generation of electricity onsite. In the EU, we are moving away from the feed-in tariff system and towards supporting self-consumption. A promising direction for SENSEI could be a model of self-consumption that is optimized to support the grid, therefore SENSEI approach for compensating changes behind the meter could support such direction.

2.1.2 Effect of energy efficiency measures on the network load profile

Each energy efficiency intervention affects the electricity grid, for the proper functioning of which, a certain transmitted power limit cannot be exceeded. This limit is the capacity of the network.

To reduce CO_2 emissions, interventions that lead to the replacement of the energy vector must be encouraged, which means abandoning the use of fossil fuels for systems that can be powered by electricity, starting from the heating system. In fact, heating buildings with heat pumps that use refrigeration cycle technology can lead to primary energy savings of between 25% and 60%.

This type of intervention leads to an increase in the reliability of the network: the requirement to carry more energy and engage users with greater power in particular circumstances may fail to satisfy the requests.

In Deliverable 4.2 of the SENSEI project, five different effects have been identified that the network absorption curve can undergo. They are shown in Figure 8.

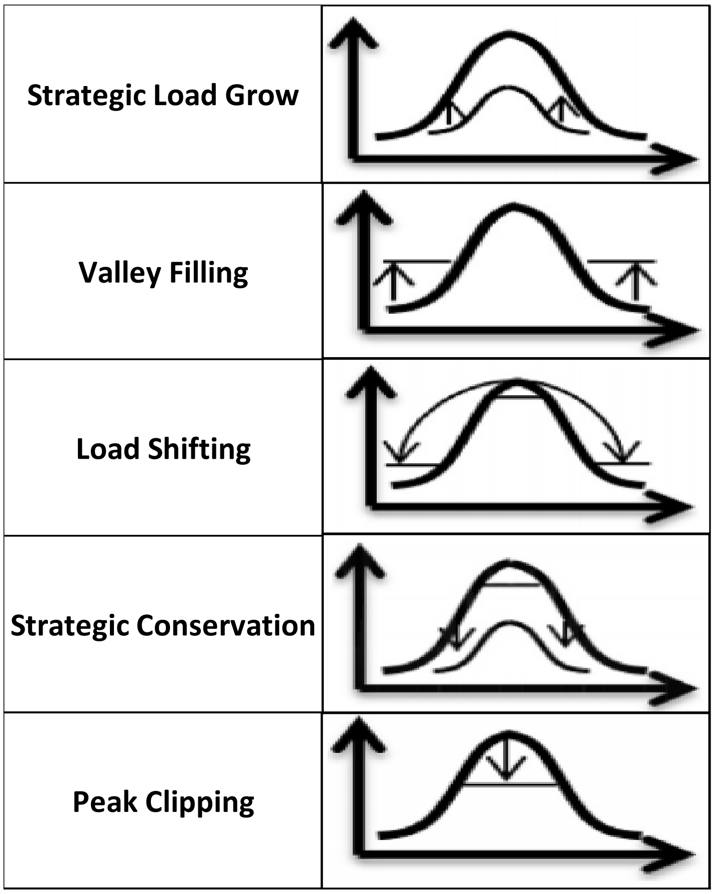


Figure 8 - Effects of an intervention on the network absorption curve

- **Strategic load grow**: this represents an increase in the energy absorbed by the network that can occur following fuel substitution measures, such as the electrification of heating systems;
- **Valley filling**: this modification of the curve is obtained by combining 2 interventions: heat pump technology and thermal storage. Heat pumps generate heat during the hours in which less energy is required from the network afterwards this energy is accumulated in thermal storage to be used in another moment;
- **Load shifting**: it is a simple case of thermal accumulation, both in terms of hot and cold sources, in this case, we would be deal with partial, daily and weekly accumulations;
- **Strategic conservation**: most of the interventions result in a simple reduction of energy absorbed by the network, although some operations may cut the absorption in some hours of the day and, in some sectors, the same aggregate interventions are expected to lose this characteristic;

- **Peak clipping**: cutting off the tips is a main characteristic of photovoltaics, but it is also caused by solar screens. These systems are an example that explains the importance that the sun plays in air conditioning. Being able to reduce the solar gain coefficient of a thermal environment can lead to an energy-saving of up to 25%.

The above analysis is a crucial point in order to allow the classification of the interventions considering the EEMs effect on the grid.

2.1.3 Analysis of energy savings

EEMs can give rise to both electrical and thermal energy savings, since electrical energy is higher quality energy, compared to thermal, a higher value will be associated with it. The difference between electrical and thermal energy will be explained in different ways to determine the right value for EEMs classes.

In order to analyze the quality of an energy efficiency intervention, we will often talk about energy saving. Such interventions will allow avoiding the production of a certain quantity of energy in traditional thermoelectric plants with subsequent savings of fossil fuels and CO2 emissions.

The quality of the intervention will be proportional to the "useful" energy. Three different situations are analysed here, for each of which the term “useful energy” has a different meaning:

- Energy efficiency in the strict sense of the term refers to the search for machines and equipment that maximize the efficiency of the entire system, intending to complete a job with the least amount of energy possible. Improving the efficiency of a system means replacing part of it to subsequently have a lower overall energy consumption. The difference between the energy used previously and the subsequent one is useful energy.
- Renewable energy plants produce energy from inexhaustible sources: the most commons are wind and photovoltaic. This energy produced can be either self-consumed on site, if the plant is connected to a user, or fed into the network. In the absence of such plants, the energy required must be supplied by traditional thermoelectric plants which have a significant environmental impact. All energy produced by renewable energy systems will be considered useful energy.
- Storage systems have the advantage of reducing the transport of energy on the network by instead favouring on-site consumption. In case the production of energy does not

coincide temporally with the demand of the same, storage systems intervene to make that energy available in a deferred moment. The capacity of the storage system multiplied by the number of charge and discharge cycles will be the starting point to calculate the useful energy.

2.2 Devising the list of EEMs

There is a great potential for energy efficiency behind all forms of energy consumption: in our homes, offices and companies, but also in our way of communicating and moving. The improvement of energy efficiency cannot be separated from a large-scale involvement of operators and citizens.

Thanks to an active energy policy regarding the rationalization of the use of energy, the European Union has achieved important results in the various consumption sectors: the energy intensity of all European economies has decreased by 17% in the last ten years (about 25% in the last twenty years)[9] and this implies an accumulated energy saving which is equal to a consumption of 132 million tons of oil equivalent.

As described in Deliverable 4.1 Energy efficiency does not participate in wholesale markets as it is not a dispatchable resource (unlike generation and demand-side response). However, energy efficiency has an indirect impact on wholesale markets. Through lowering demand, it results in lower wholesale market prices, an effect called the demand reduction induced price effect (DRIPE). DRIPE is a measurement of the value of efficiency in terms of reduction of wholesale energy prices seen by all retail customers. Reduced energy demand due to efficiency programs allows the shedding of the most expensive resources on the margin and lowering the overall costs of energy. This reduces the wholesale prices of energy and demand, and this reduction, in a relatively deregulated market, is in theory passed on to retail customers.

While the reduction rates caused by decreased demand are usually small (expressed in fractions of a cent per kWh) their absolute value can be quite large as it is spread across all of the customers in the market.

The large absolute value of energy efficiency's price effects can, in turn, dramatically change the cost-benefit analysis of additional investments in energy efficiency. Producing accurate and

[9] https://www.aceee.org/files/proceedings/2015/data/papers/5-91.pdf

reliable estimates of the total price effects of energy efficiency investments, therefore, becomes very important, as well as inaccurate estimates or total exclusion of price effects can lead to an inefficient level of energy efficiency investment.

For the above reasons a detailed classification of the EEMs was conducted taking into account technical (e.g. the effect of an intervention on the grid load profile) and economic parameters. The classes of EEMS will be very helpful for the development of the P4P schemes in the framework of SENSEI project.

2.2.1 Categorization of EEMs

In literature[10], the building sector's different kinds of energy efficiency interventions are known. Thus, in this study different categories have been identified according to the principle with which energy is saved. The category of energy efficiency in the strict sense of the term is vast, therefore it is subdivided into sub-categories:

- Distributed generation plants
- Storage systems
- Conversion from fuel to electric
- Interventions that reduce energy needs
    - Building envelope
    - Thermal plant
    - Electrical system
    - Automatic building control systems

Table 3 shows a full list of energy efficiency interventions grouped by category and assigned with a progressive number. The possibility of carrying out the same intervention for three sectors has been expressed: **Residential, Industrial and Commercial.** *The 3 sectors are explained better below.*

- **Residential sector**: An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration,

[10] https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568361/EPRS_BRI(2015)568361_EN.pdf

cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters

- **Commercial sector**: An energy-consuming sector that consists of service-providing facilities and equipment of businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments
- **Industrial sector**: An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products

The results of an energy efficiency intervention generate profoundly different outcomes depending on whether the intervention is carried out on different types of buildings and systems. Furthermore, some interventions are not configured for some sectors, therefore it becomes useful to introduce this differentiation. To differentiate the three sectors, the following abbreviations have been associated respectively: ***Res*** **for Residential,** ***Ind*** **for Industrial and Com for Commercial**. The combination of one number with one abbreviation determines a unique identification code (ID): for example, intervention *1 Res* will be the installation of a photovoltaic system in the residential sector.

CATEGORY	N	INTERVENTION	Residential	Industrial	Commercial
DISTRIBUTED GENERATION	1	Photovoltaics	X	X	X
	2	Wind		X	
	3	Solar collectors	X		X
	4	Cogeneration	X	X	X
	5	Trigeneration		X	X
STORAGE SYSTEMS	6	Batteries	X	X	X
	7	Hydroelectric		X	
	8	Compressed air		X	
	9	Hydrogen		X	X
	10	Thermal storage	X	X	X
	11	Refrigerator storage		X	X
CONVERSION OF THE ENERGY CARRIER	12	Heat pump	X	X	X
	13	Electric vehicles		X	
BUILDING ENVELOPE	14	Thermal coat	X	X	X
	15	Fixtures	X	X	X
	16	Solar screens	X	X	X
THERMAL SYSTEMS	17	District heating		X	
	18	Heat recovery		X	X
	19	Heat pump	X	X	X
	20	Diffusers	X	X	X
	21	Hydronic appliances	X		X
	22	DHW recovery	X		X
	23	Circulators	X		X
	24	Fans		X	X
ELECTRICAL SYSTEMS	25	LED	X	X	X
	26	Electric engines		X	X
	27	Capacitor bank		X	X
	28	Optimizers	X	X	X
BUILDING AND AUTOMATION CONTROL SYSTEMS	29	Heating		X	
	30	Domestic hot water		X	
	31	Cooling		X	
	32	Ventilation and Conditioning		X	
	33	Lighting		X	
	34	Solar screens		X	
	35	TBM systems		X	

Table 3–Full list of energy efficiency measures

Legend
kWhe saved
kWht saved

2.2.2 List of EEMs

A general description of the interventions that have been analysed in this study is provided below. The description is realized for each category listed in section2.2.1

DISTRIBUTED GENERATION PLANTS

1) **Photovoltaic**: simple systems installed on the ground or buildings, concentration, or tracking types are excluded. The plant is connected in parallel to the electricity grid and islanding is not foreseen.[11]

2) **Wind power**: to be profitable, wind plants must be installed in locations where the wind is strong, constant and present for many hours a year. Wind generators have powers that can range from a few kW up to more than one MW. In this study, we focused on a size that can be installed by a single user moving away from the common image of multimegawatt systems.[12]

3) **Solar collectors**: they are an excellent solution for the production of domestic hot water, their drawback implies complex management therefore often they need an auxiliary generator. Panels with a surface of 2.2 m^2will be considered including a 150-liter storage tank for each panel (commercial solution).[13]

4) **Cogeneration**: cogeneration techniques are manifold but we will limit ourselves to considering internal combustion engines and gas micro turbines. Recently, these systems have been made reliable and marketed also in the residential sector, providing the energy that an average user needs at an appropriate cost.[14]

---

[11]https://blog.aurorasolar.com/how-a-photovoltaic-system-produces-electricity/

[12]https://www.energy.gov/eere/wind/how-do-wind-turbines-work

[13]https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/solco_training_solar_collectors_en.pdf

[14]https://www.researchgate.net/publication/328344774_Review_of_cogeneration_and_trigeneration_systems

5) **Trigeneration**: simultaneous production of electricity, heat and cooling energy. This type of system is very complicated and difficult to manage so its investment costs are justified for large plants, for which the work of many hours per year and maintenance is performed in a workmanlike manner.[15]

STORAGE SYSTEMS

6) **Electric**: storage batteries are a rather expensive technology, for this reason, they have only recently broken through the market. The advantages of their application are: reducing the energy that is being transmitted in the network, to increase the self-consumption of a system that produces electricity and, in some cases, to operate the system in isolation.[16]

7) **Hydraulic**: it is represented by hydroelectric storage systems. This type of system is a pillar of national energy storage (in the United States it represents 95%). Nowadays we must try to overturn this technology to the individual user. The advantages compared to other types of storage are linked to reduced energy costs and very reliable technology, the disadvantage consists of the initial commitment in terms of space, money and design.[17]

8) **CAES**: compressed air systems have been studied for many years to be able to overcome the serious problems that this technology suffers from. Unlike the hydraulic accumulation, to have given energy, much more air must be processed to bring the accumulation tank equally large (in some cases the subsoil is used). , Moreover, the losses that occur when the system is stopped are considerable which makes them generally uninteresting except for continuous applications.[18]

9) **Hydrogen**: is another relatively new technology because fuel cells are thought to be the future of the automotive industry. Depending on the type, they can use different fuels but the most valuable is hydrogen. To obtain the latter, for 99% of world production, we

---

[15] https://www.researchgate.net/publication/328344774_Review_of_cogeneration_and_trigeneration_systems

[16] https://www.irena.org/costs/Electricity-Storage

[17] https://www.energy.gov/eere/water/pumped-storage-hydropower

[18] https://www.ctc-n.org/technologies/compressed-air-energy-storage-caes

start from fossil fuels. In an ideal network, however, there is no longer the presence of fossil fuels so the alternative to produce hydrogen is the electrolysis of water: this is a very energy-consuming process but once the fuel is obtained it is stable for an indefinite time which makes the technology very flexible and interesting, but on the other hand has very high investment costs.[19]

10) **Thermal**: excellent results in combination with heat pump heating. The time lag between the demand and the production of heat offered by the storage allows the machine to work in off-peak hours of the network and at better temperatures.[20]

11) **Refrigerator**: this technology is similar to the previous one with particular emphasis on the functioning of the heat pump at optimum temperatures, very cool temperatures at night allow to work at very high COP values.[21]

CONVERSION OF ENERGY CARRIER

12) **Heat pump**: the technology of reverse thermodynamic cycles applied to heating is so efficient that it almost becomes an obligation to use it. Through reverse steam cycles, heat pumps are capable to transfer great quantities of heat from cold to warm environments. The operation of the machine is not easy to understand, however, there is a parametron that tells us how much thermal energy is provided for each unit of electricity: it is the COP (coefficient of performance) which varies from 2 to 5. The primary energy saving is in the function of the national electrical efficiency and of the COP: for example, using a boiler with an efficiency of 0.92 for each unit of incoming gas, 0.92 units of useful heat will be obtained; if the same unit was burnt in the plant, 0.46 units of electricity were obtained (national electrical efficiency),[22]

13) **Electric vehicles** are the means of transport of the future, their advantages are manifold and the market is growing rapidly and is very varied. For this reason, we specified that

[19]https://americanhistory.si.edu/fuelcells/basics.htm

[20]https://www.irena.org/publications/2013/Jan/Thermal-energy-storage

[21]https://www.energydepot.com/RPUcom/library/HVAC015.asp

[22]https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2013/08/BolesLectureNotesThermodynamicsChapter10.pdf

for our study, we refer to an economic car of the current market, excluding luxury models. To make a comparison of energy saving, the following data are used:

- Diesel car: diesel fuel 9.88 kWh / L consumption 20 km / L.
- Life duration 150000 km.
- Electric car: average consumption 0.13 kWh / km.
- Electric / traditional car cost variation + 35%.[23]

BUILDING ENVELOPE

14) **Thermal coat**: it is common practice to install insulating panels during the construction of a building, these serve to reduce the heat losses that occur to run with the external environment. The benefit is not seen only in winter but also in summer, moreover, there are legal limits for the transmittance of new buildings which often lead to the use of insulators. An intervention that reduces the transmittance on average by 0.4 W / mc ° K will be considered.[24]

15) **Door and windows fixtures**: fixtures have a great influence on the thermal balance of a building, in fact even if they are small they have rather high transmittance values. For this reason, the market is being renewed with: thermal break frames, double glazing, low emission glass, etc. In our study we will consider an intervention that reduces the transmittance on average by 2 W / mc ° K.[25]

16) **Solar screens**: the installation of solar screens has the effect of limiting the amount of heat that the sun transmits into a building through transparent surfaces. Mainly it is thought that this useful technology was exclusive in the summer but it is not so, in fact there are commercial buildings with human activity inside that require cooling also in winter. The use of such systems leads to energy savings of up to 25%.[26]

THERMAL SYSTEMS

[23] https://www.cars.com/electric-cars/

[24] https://www.designingbuildings.co.uk/wiki/Thermal_insulation_for_buildings

[25] https://uk.saint-gobain-building-glass.com/en-gb/glass-and-thermal-insulation

[26] https://insolroll.com/how-solar-screen-shades-work/

17) **District heating**: it is a form of heating which consists in the distribution through networks of insulated pipes of hot, superheated water or steam coming from a large production plant. The advantages are a more efficient use of primary energy, both when it is carried out in cogeneration plants and when waste heat from industrial processes is used; there are greater controls on exhaust gases and reduction of pollutants. The main disadvantage is a higher sold energy cost compared to other sources (biomass, methane, LPG).[27]

18) **Heat recovery**: this intervention refers to air conditioning systems that absorb a good portion of the national energy, therefore a heat recovery between the air currents leaving and entering the buildings leads to considerable savings. The most used recuperators are plate and rotary type.[28]

19) **Heat pump**: the replacement of heat pumps is a very important intervention if the efficiency of the network has to be achieved. Being a reliable technology and marketed for many years, many users would need an update, to reach 20% savings.[29]

20) **Diffusers**: the devices for introducing air into the environment are multiple and profoundly different; they are described by different parameters such as range, residual speed, pressure drop, flow rate, regulation and induction coefficient. Depending on all these parameters, the supply of air temperature changes and consequently the heat demands inside the air treatment unit.[30]

21) **Hydronic devices**: heat pumps work between 2 thermal sources: the first one is represented by external air from water or ground, the second one is the water that comes from the heating or cooling system. Being able to bring the temperature of the system water closer to the external thermal source allows the machine to work at higher COP values. This is obtained by modifying the emission terminals of the system.

[27]https://www.frontiersin.org/articles/10.3389/fbuil.2016.00022/full

[28]http://www.thermopedia.com/content/832/

[29]https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2013/08/BolesLectureNotesThermodynamicsChapter10.pdf

[30]http://www.airvent.com/ventilation-resources

Regarding heating, we can have radiators that work at 55 ° C up to radiant floors that work at 35 ° C.[31]

22) **DHW recovery**: From 5 April the new UNI TS 11300-2: 2019 standard came into force which consists in the reduction of primary energy in presence of heat recovery systems from waste water that comes showers. It is possible to recover from 30% to 40% of the heat contained in waste water from showers, sinks and / or tubs.[32]

23) **Circulators**: circulators are hydraulic pumps that work in a closed circuit, they are characterized by low head and high flow values. They work for a large number of hours per year therefore their efficiency can lead to important energy savings.[33]

24) **Fans**: these machines are very sensitive to coupling with the aeraulic network, therefore their replacement following any changes that the system could immediately bring could lead to discrete energy savings.

ELECTRICAL SYSTEMS

25) **LED**: lighting is not a field considered to be very important within an electrical system, because in residential users it has a low consumption even though this does not happen in the industrial and commercial sectors where luminaires work for a large number of hours per year.[34]

26) **Electric motors**: 75% of the electricity consumed in the industrial sector is used to power electric motors, these are classified according to energy efficiency classes "IE", established by the international standard IEC 60034-30: 2008. [35]

[31] http://www.healthyheating.com/Heat-Terminal-Units/Heat-terminal-units.htm#.XtDOejozYYw

[32] https://www.thegreenage.co.uk/tech/waste-water-heat-recovery-systems/

[33] http://www.watergas.it/grk_files/uploads/grundfos_pompe_italia/news/grundfos_partecipa_alla_fiera_/downloads/hvac_oem_ish__newsletter_2017b.pdf

[34] https://www.rohm.com/electronics-basics/leds/what-are-leds

[35] https://www.explainthatstuff.com/electricmotors.html

Figure 9 - Example of an electric motor

27) **Capacitor bank**: electric motors and transformers are inductive loads which absorb both active and reactive power; the reactive power averaged over time has zero value, it is absorbed in some instants and is transferred to the network in others. This transit of power on the grid lines entails higher currents and similar losses. The capacitors operate opposite to the standard motors.[36]

Figure 10 - Example of a capacitors bank

28) **Optimizers**: the voltage stabilizers are devices that rigorously control the trend of the electrical voltage by eliminating unnecessary energy transits in the network, saving 10% of energy.[37]

BUILDING AND AUTOMATION CONTROL SYSTEMS

29) **BACS**: active energy efficiency systems, such as building and automation control systems, have the function of maximizing the energy efficiency of buildings technical systems concerning the external environmental conditions and the different profiles of use and occupation of the individual environments. The EN 15232 standard, which

[36] https://electrical.theiet.org/media/1687/power-factor-correction-pfc.pdf

[37] https://www.analog.com/en/technical-articles/how-voltage-regulator-works.html#

introduced a classification of control functions of technical building systems, is the starting point for their implementation and their estimation on energy performance. [38]

2.3 Devising classes of EEMs

The classification of schemes of EEMS results from the definition of 3 tables and their integration. We devised 3 different tables, each of which conducts an independent analysis, to evaluate the EEMs:

1. Table A: Grid effects.
2. Table B: Building benefits.
3. Table C: Value of measures.

In particular, **Table A** contains a qualitative analysis of the effects on the grid; **Table B** explains a technical qualitative analysis with details of users' benefits; **Table C** shows a quantitative analysis.

At the end of each analysis a class of goodness is resulted from each EEM, from the higher value (A) to the lower (J).

A conclusive evaluation that integrates the effects of the 3 tables resulted in the Class X, as the classes of EEMs.

2.3.1 Table A: Grid Effects

Table A provides a summary analysis of the quality of the intervention, all technical aspects are considered jointly to leave room for the effect that the intervention has on the electricity grid.

Table A contains 3 parameters to determine the class of evaluation:

- ***Energy***: this value will be as high as the useful energy expected from the intervention because electricity is considered to have a higher value than thermal energy (values from 1 to 5)

[38] http://www.altecon.it/highlights/en-15232

- ***Conversion***: valid only for the category in which the energy carrier is replaced (values from 1 to 5)
- ***Network***: the effects on the grid described in Figure 8reflects the values shown in the Table 4:

0.7	Strategic Load Grow
0.8	Valley Filling
1	Load Shifting
1.2	Strategic Conservation
1.3	Peak Clipping

Table 4 - Values assigned to the network effects due to the EEMs

Each intervention will therefore have a value proportional to its goodness calculated as follows:

$$ValueA = (Energy + Conversion) * Grid\ benefit$$

Starting from Value A it is possible to determine the class according to the following equation:

:

$$Class\ Table\ A = INT\left(\frac{ValueA * 10}{MAX(ValueA)} + 0,5\right)$$

Table 5 Table 5 summarizes the classes of EEMs for Table A:

Legend	
Res	residential
Ind	industrial
Com	commercial

EEM name	EEM ID	Class Table A
Photovoltaics	1 Res	C
	1 Ind	C
	1 Com	C
Wind	2 Ind	A
Solar collectors	3 Res	E
	3 Com	E
Cogeneration	4 Res	E

	4 Ind	C
	4 Com	C
trigeneration	5 Ind	C
	5 Com	C
Batteries	6 Res	F
	6 Ind	F
	6 Com	F
Hydroelectric	7 Ind	E
CAES	8 Ind	E
Hydrogen	9 Ind	E
	9 Com	E
Thermal storage	10 Res	F
	10 Ind	F
	10 Com	F
Refrigerator storage	11 Ind	F
	11 Com	F
Heat pump	12 Res	B
	12 Ind	A
	12 Com	A
Electric vehicles	13 Ind	C
Thermal coat	14 Res	E
	14 Ind	G
	14 Com	C
Fixtures	15 Res	E
	15 Ind	I
	15 Com	G
Solar screens	16 Res	E
	16 Ind	G
	16 Com	C
District heating	17	C
Heat recovery	18 Com	E
Heat pump	19 Res	G
	19 Ind	E
	19 Com	E
Diffusers	20 Res	G
	20 Ind	E
	20 Com	E
Hydronic appliances	21 Res	E
	21 Com	E
DHW recovery	22 Res	E
	22 Com	E
Circulators	23 res	G
	23 Com	E
Fans	24 Ind	G
	24 Com	E

LED	25 Res	E
	25 Ind	C
	25 Com	C
Efficient electric motors	26 Ind	C
	26 Com	A
Capacitor bank	27 Ind	E
	27 Com	C
Optimizers	28 Res	E
	28 Ind	C
	28 Com	C
Heating	29	G
Domestic hot water	30	G
Cooling	31	G
Ventilation and Conditioning	32	E
Lighting	33	E
Solar screens	34	G
TBM systems	35	G

Table 5– Classes of EEMs for Table A

Legend	
Res	residential
Ind	industrial
Com	commercial

The classes obtained for Table A are shown also, for each sector analyzed, in the figures below. Let us recall here the **Errore. L'origine riferimento non è stata trovata.** mapping from the higher value (A=10) to the lower (J=1).

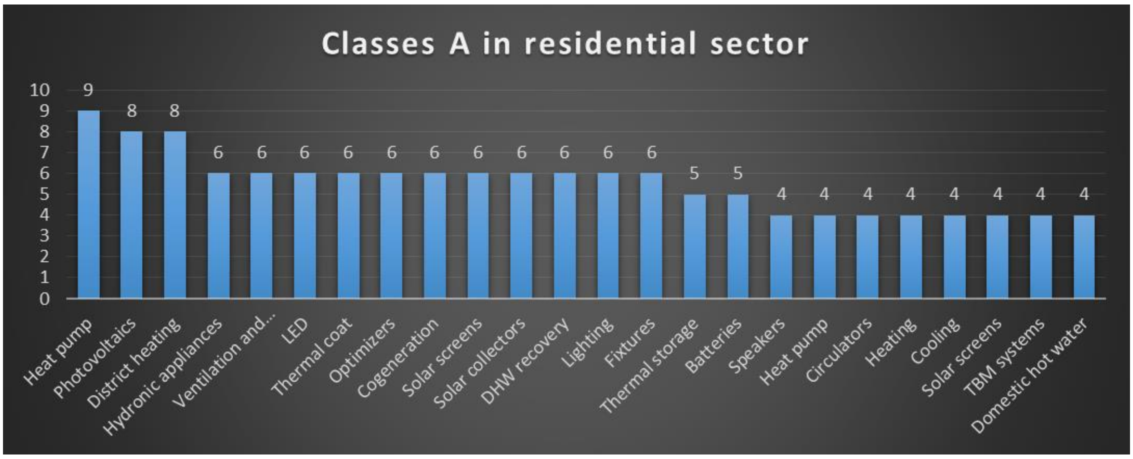


Figure 11 - Classification obtained according to Table A for the most significant EEMs in Residential sector

Figure 12 - Classification obtained according to Table A for the most significant EEMs in Industrial sector

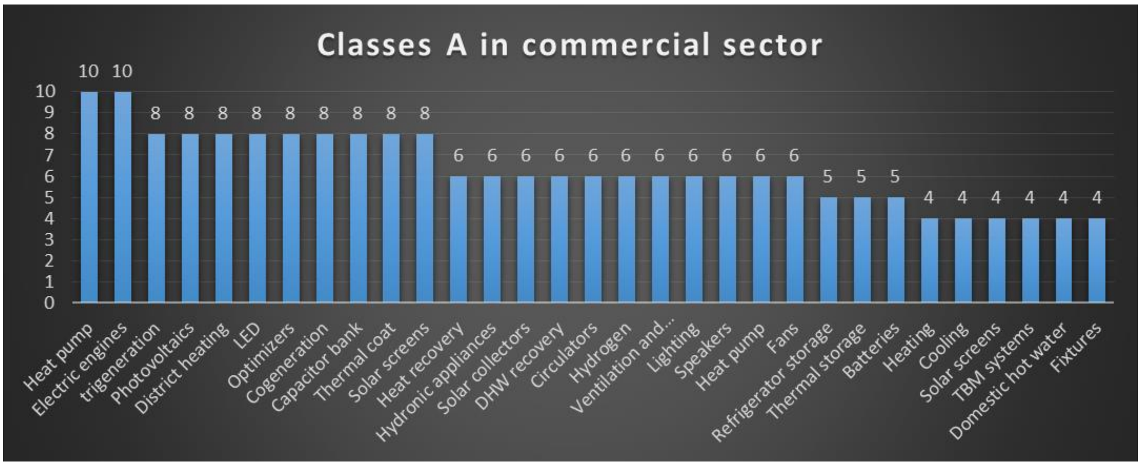


Figure 13 - Classification obtained according to Table A for the most significant EEMs in Commercial sector

It is immediately evident that the category of distributed generation provides the best results: in fact, it gives a great benefit to the user in terms of energy and frees the network from the transmission of a lot of energy.

The heating systems mainly generate direct thermal energy savings and indirect electricity savings, therefore they have reduced energy values which leads to lower class values for all interventions.

A similar situation occurs with BACS due to the small energy savings.

However, this analysis does not take into account important elements such as the financial commitment for the implementation of the intervention and the associated risk.

2.3.2 Table B: qualitative analysis

Table B analyses various technical and economic aspects of the interventions, some of the terms have positive and some negative values. Each quantity will receive a numerical evaluation from 1 to 5.

Table B contains several parameters to better judge the technical quality of the intervention, to each parameter a weight is assigned in order to add the products of vote and weight. The parameters used to determine the values of Table B are divided as follows:

- Positive terms:
  - *Benefit*: amount of useful energy, Weight (W_b)=1
  - *Duration*: proportional to the useful life of the intervention, Weight (W_d)=0.75
  - *End of life benefit*: ratio between the benefit at the end of life and at the beginning of life, Weight (W_{EoL})=0.75
  - *Innovation*: new technology with low market penetration, Weight (W_i)=0.5
  - *Comfort*: variation of comfort felt by the users following the intervention (rating 3 corresponds to variation 0),Weight (W_c)=0.5
- Negative terms:
  - *Investment*: specific cost of the intervention, Weight (W_{Inv})=0.75
  - *Measure*: difficulty and costs in verifying the savings following the intervention, Weight (W_m)=0.75
  - *Risk*: probability that the intervention does not lead to benefits at the end of its useful life, Weight (W_r)=0.5

The benefit of the intervention is the only parameter to have a unit weight to follow the philosophy of the " Energy Efficiency first principle". Once the value B is obtained, it is possible to evaluate the classification of table B:

$$Class\ Table\ B = INT\left(\frac{ValueB * 10}{MAX(ValueB)} + 0,5\right)$$

The calculation of the *Value B* term derives from:

$$Value\ B = (Benefit * W_b + Duration * W_d + EoL\ benefit * W_{EoL} + Innovation * W_i + Comfort * W_c) - (Investment * W_{Inv} + Measure * W_m + Risk * W_r)$$

In Table 6 the classes of EEMs for Table B are shown:

EEM name	EEM ID	Classes for Table B
Photovoltaics	1 Res	D
	1Ind	A
	1 Com	A
Wind	2Ind	B
Solar collectors	3 Res	F
	3 Com	D
Cogeneration	4 Res	F
	4 Ind	F
	4 Com	F
trigeneration	5 Ind	G
	5 Com	G
Batteries	6 Res	E
	6 Ind	E
	6 Com	E
Hydroelectric	7 Ind	D
CAES	8 Ind	F
Hydrogen	9 Ind	E
	9 Com	E
Thermal storage	10 Res	E
	10 Ind	F
	10 Com	F
Refrigerator storage	11 Ind	G
	11 Com	G
Heat pump	12 Res	D
	12 Ind	D
	12 Com	D
Electric vehicles	13 Ind	C
Thermal coat	14 Res	C
	14 Ind	A
	14 Com	A
Fixtures	15 Res	G
	15 Ind	G
	15 Com	G
Solar screens	16 Res	H
	16 Ind	E
	16 Com	E
District heating	17	F
Heat recovery	18 Com	C
Heat pump	19 Res	D
	19 Ind	D
	19 Com	D
Diffusers	20 Res	G

	20 Ind	E
	20 Com	D
Hydronic appliances	21 Res	D
	21 Com	B
DHW recovery	22 Res	G
	22 Com	F
Circulators	23 Res	G
	23 Com	E
Fans	24 Ind	E
	24 Com	E
LED	25 Res	B
	25 Ind	C
	25 Com	B
Efficient electric motors	26 Ind	F
	26 Com	F
Capacitor bank	27 Ind	F
	27 Com	F
Optimizers	28 Res	E
	28 Ind	B
	28 Com	B
Heating	29	B
Domestic hot water	30	B
Cooling	31	B
Ventilation and Conditioning	32	B
Lighting	33	C
Solar screens	34	C
TBM systems	35	C

Table 6 - Classes of EEMs for Table B

Legend	
Res	residential
Ind	industrial
Com	commercial

Compared to table A, we now have a more differentiated classification of the interventions in output. The best ones are the installation of photovoltaic systems and the construction of thermal coats, both in the industrial and commercial sectors. Storage systems, because of their initial cost and need for maintenance have poor Class B values. At the same time for the simplicity of their installation, BACS have better values than class A. The heating system is the one present. The more diversified values testify that table B is a good evaluation tool for EEMs.

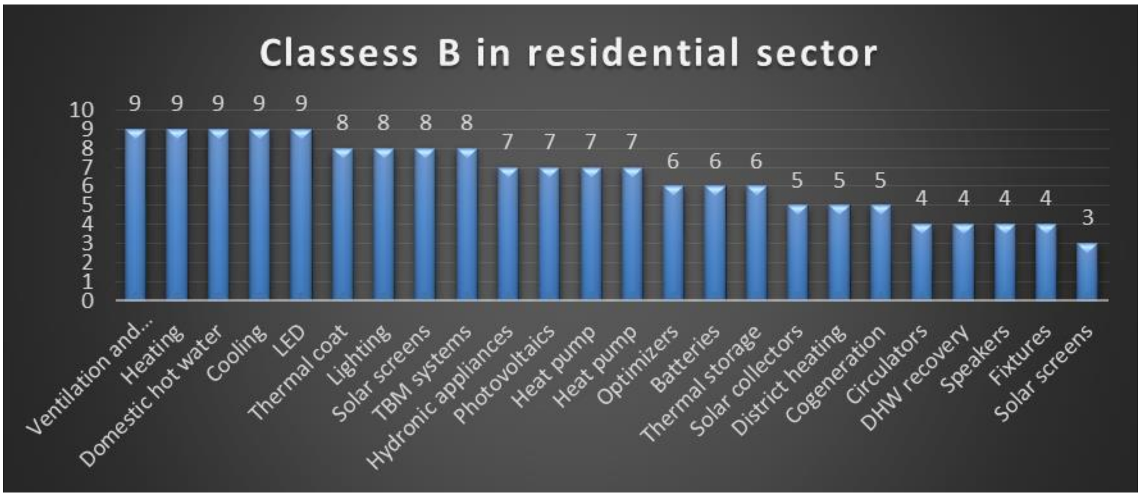


Figure 14 - Classification obtained according to Table B for the most significant EEMs in Residential sector

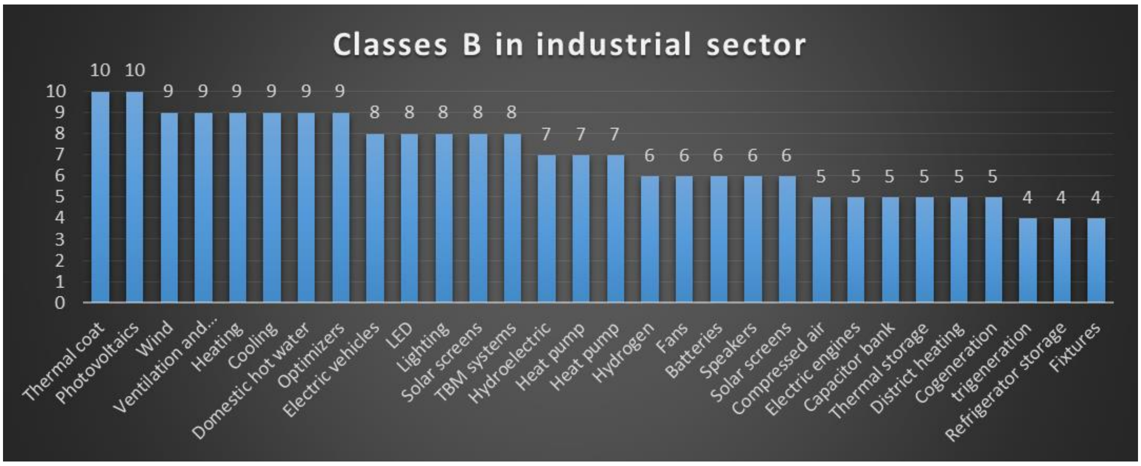


Figure 15 - Classification obtained according to Table B for the most significant EEMs in Industrial sector

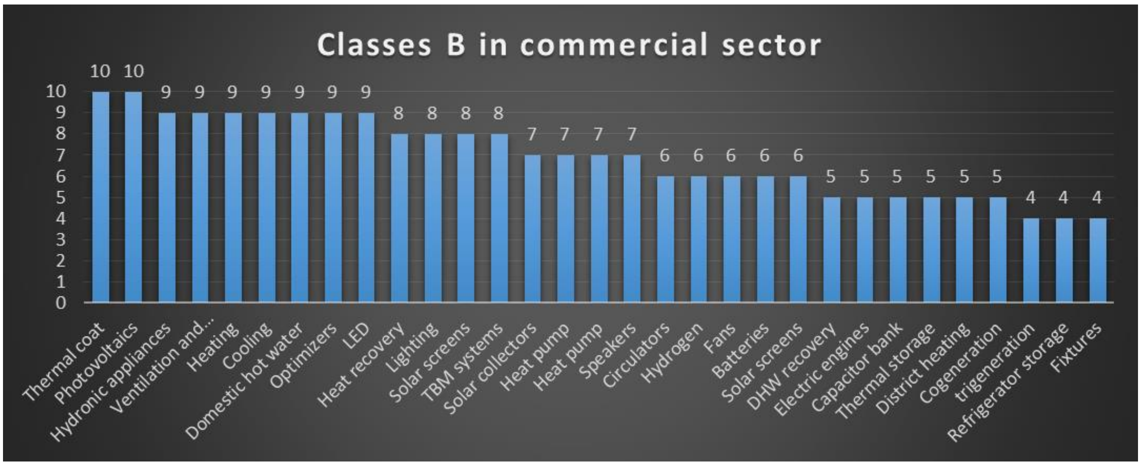


Figure 16 - Classification obtained according to Table B for the most significant EEMs in Commercial sector

2.3.3 Table C: quantitative analysis

Compared to the previous two tables, Table C evaluates a large number of parameters in order to calculate with some uncertainty the energy saving by taking into consideration the financial and economic aspects of the energy efficiency measures.

A fixed investment is considered, which determines the size of the measure. Depending on the energy efficiency intervention one of the following variables is identified:

- Nominal power;
- Storage capacity;
- Unit;
- Surface.

A complete list of the parameters shown in table 3 is reported below:

- Power [**P**]: nominal power of the installed plant or machine [kW];
- Capacity [**C**]: energy accumulated by the system [kWh];
- Units [**N**]: number of pieces that can be purchased [-];
- Surface [**S**]: extension of the intervention [m2];
- Duration [**n**]: physical life of the intervention [years];
- Producibility [**Pr**]: specific energy produced by the system [kWh / kW * year or kWh / m^2 * year];
- Annual equivalent hours [h_{eq}]: full-scale operation equivalent to actual operation [h / year]
- Cycles [**cycles**]: number of charge and discharge cycles that the storage systems can carry out [-];
- Cyclic efficiency [η_c]: efficiency which includes the conversion and storage of energy [%];
- Decay [**dec**]: loss of producibility / efficiency at the end of its useful life [%];
- Consumption [**con**]: energy used by the machine over its useful life [kWh / unit];
- Requirements [**Fabb**]: average annual specific energy consumption of buildings [kWh / m^2];
- Savings [**sav**]: containment of heat energy losses [kWh / m^2 * year];

- Efficiency [**eff**]: ratio between energy consumption in ANTE and POST situations [-];
- Conversion factor [**f**]: factor that binds the thermal electric kWh to the TOE [kWh / TOE];
- Energy saving [**E**]: energy saved thanks to the intervention for the whole life span [TOE];
- Maintenance [**main**]: maintenance costs [€ / year];
- Measure [**meas**]: cost to measure the actual savings [€];
- Investment [**I**]: sum of the various cost items [€];
- Energy value [$\mathbf{c_e}$]: money value of the useful energy [€/TOE]
- Margin [**m**]: monetary value of the energy efficiency intervention [€];

As the energy efficiency intervention changes, different parameters are taken into consideration to calculate the useful energy.

The equations used for each of the interventions are explained below:

EEM ID category	Equation [TOE]
1,2	$P * Pr * n * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
3	$S * Pr * n * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
4,5	$P * h_{eq} * n * \left(1 - \frac{dec}{2}\right) * (eff - 1) * \frac{1}{f}$
6-11	$C * cycles * \eta_c * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
12	$P * h_{eq} * n * (eff - 2) * \frac{1}{f}$
13	$N * con * (eff - 2) * \frac{1}{f}$
14-16	$S * sav * n * \frac{1}{f}$
17,29-35	$S * n * Fabb * (eff - 1) * \frac{1}{f}$
18-21,23-28	$P * h_{eq} * n * (eff - 1) * \frac{1}{f}$
22	$N * n * con * (eff - 1) * \frac{1}{f}$

Table 7 - Calculation of useful energy for energy efficiency measures

For each intervention, there will be a quantity of useful energy together with the total lifetime costs of the intervention. Once a value will be assigned to the saved energy, the profit margin will be calculated as follows:

$$(E * c_e) - (I + main * n + meas) = Margin$$

The value of saved energy was supposed to be 10,00 *€cent/kWh*.

For each parameter there are average values and standard deviations that need to be calculated for the risk of the intervention: this will be defined as the probability that the margin is negative(please see APPENDIX B – Formulary).

$$Risk = Probability\ (Margin < 0)$$

This result will be inversely proportional to the quality of the class according to the Table 8:

Risk min	Table C Class	Risk max
0%	A	2%
2%	B	5%
5%	C	10%
10%	D	15%
15%	E	20%
20%	F	30%
30%	G	40%
40%	H	50%
50%	I	75%
75%	J	100%

Table 8 - Classes of EEMs for Table C calculated according to the risk values

Table 8 maps the class value (in alphabetical term) and the related risk levels: e.g. if the risk value is between 15% and 20% class E is associated.

Table 9 shows the classes of EEMs for Table C:

EEM name	EEM ID	Table C Class
Photovoltaics	1 Res	C

	1 Ind	C
	1 Com	C
Wind	2 Ind	B
Solar collectors	3 Res	D
	3 Com	C
Cogeneration	4 Res	F
	4 Ind	B
	4 Com	B
trigeneration	5 Ind	C
	5 Com	C
Batteries	6 Res	I
	6 Ind	I
	6 Com	I
Hydroelectric	7 Ind	B
CAES	8 Ind	B
Hydrogen	9 Ind	E
	9 Com	E
Thermal storage	10 Res	C
	10 Ind	B
	10 Com	B
Refrigerator storage	11 Ind	C
	11 Com	C
Heat pump	12 Res	B
	12 Ind	B
	12 Com	B
Electric vehicles	13 Ind	F
Thermal coat	14 Res	B
	14 Ind	B
	14 Com	B
Fixtures	15 Res	G
	15 Ind	G
	15 Com	G
Solar screens	16 Res	B
	16 Ind	B
	16 Com	B
District heating	17	H
Heat recovery	18 Com	D
Heat pump	19 Res	C
	19 Ind	B
	19 Com	B
Diffusers	20 Res	E
	20 Ind	B
	20 Com	A
Hydronic appliances	21 Res	B
	21 Com	A

DHW recovery	22 Res	E
	22 Com	B
Circulators	23 Res	H
	23 Com	C
Fans	24 Ind	C
	24 Com	A
LED	25 Res	B
	25 Ind	B
	25 Com	B
Efficient electric motors	26 Ind	B
	26 Com	B
Capacitor bank	27 Ind	C
	27 Com	C
Optimizers	28 Res	B
	28 Ind	B
	28 Com	B
Heating	29	D
Domestic hot water	30	G
Cooling	31	E
Ventilation and Conditioning	32	A
Lighting	33	F
Solar screens	34	F
TBM systems	35	F

Table 9 – Classes of EEMs for Table C

Legend	
Res	residential
Ind	industrial
Com	commercial

Table 9Table 9 shows that we could have very safe (in terms of a low-risk value) EEMs to be carried out, which might easily lead to energy savings and other interventions that are too difficult to realize in economic terms.

The analysis reported above does not demonstrate that the EEMs that are more difficult to implement due to economic variables do not provide other benefits to the user and the grid.

For this reason, an integration table (Table X) has been devised, that combines the values of the previous three tables (A, B and C) into one, in order to evaluate the EEMs globally. In the next section this approach is described and the results are explained.

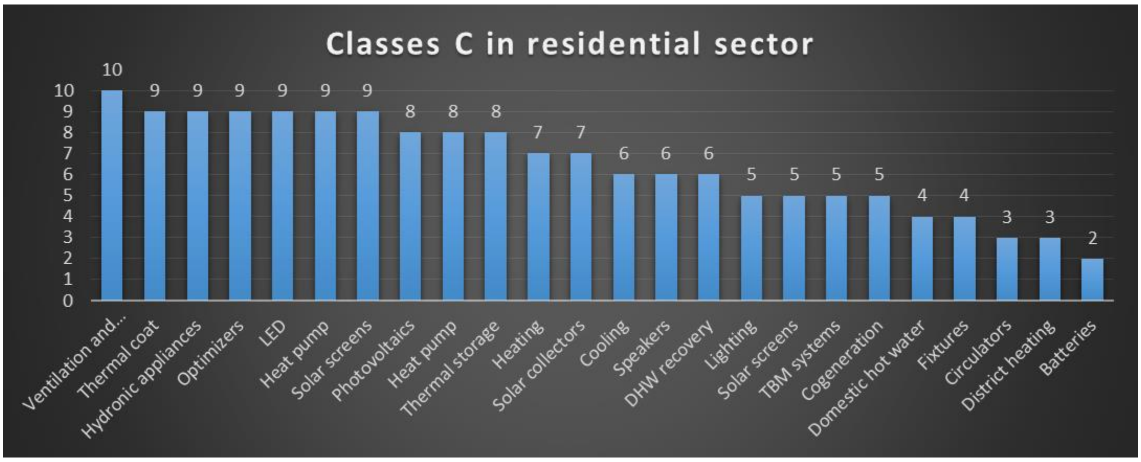


Figure 17 - Classification obtained according to Table C for the most significant EEMs in Residential sector

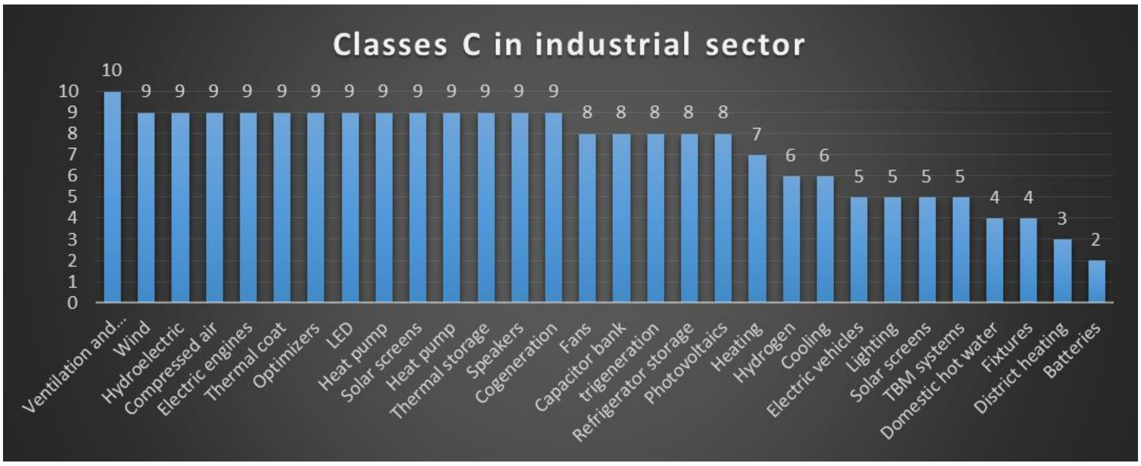


Figure 18 - Classification obtained according to Table C for the most significant EEMs in Industrial sector

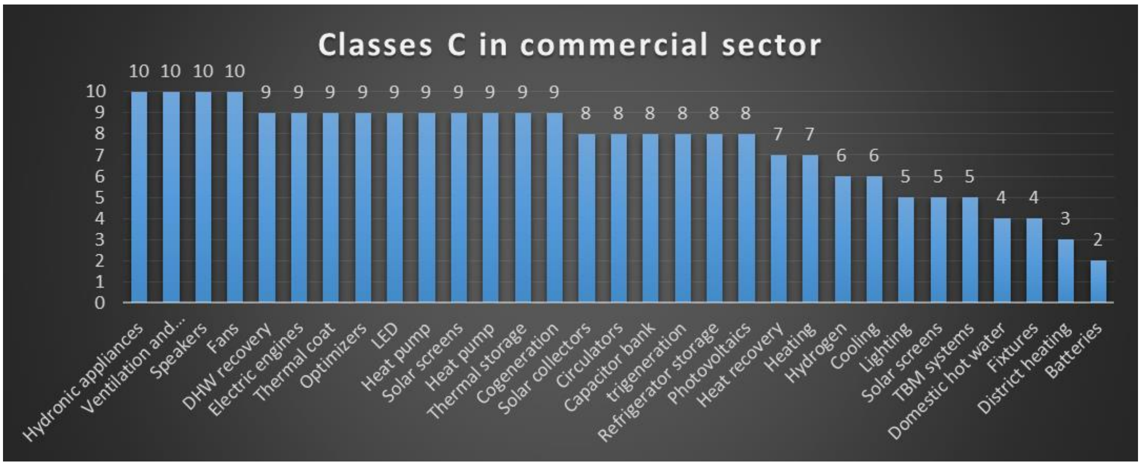


Figure 19 - Classification obtained according to Table C for the most significant EEMs in Commercial sector

2.3.4 Table X as collector of previous tables

As mentioned above, class X is a fusion of the analysis conducted in the 3 previous tables.

The following equations show the procedure for obtaining the *Value X* and related *Classes of EEMS for Table X:*

$$ValueX = \frac{ValueA + ValueB}{2} + 12 * LOG\left(\frac{1}{\sqrt{Risk}}\right)$$

The square root has been introduced to show results more aligned with each other and not to penalize the worst interventions in class C; the value of 12 was chosen to align the maximum values of the first term and the second term.

$$Class\,Table\,X = INT\left(\frac{ValueX * 10}{MAX(ValueX)} + 0{,}5\right)$$

The classes of EEMS are shown in

Table 10Also in this case the colours used are not casual but they reflect the categorization of the paragraph 2.2.1 Classification Categorization of EEMs:

Legend	
Res	residential
Ind	industrial
Com	commercial

EEMs name	EEM ID	Class
Photovoltaics	1 Res	D
	1 Ind	C
	1 Com	C
Wind	2 Ind	B
Solar collectors	3 Res	E
	3 Com	D
Cogeneration	4 Res	G
	4 Ind	C
	4 Com	C
trigeneration	5 Ind	D
	5 Com	D
Batteries	6 Res	H
	6 Ind	G
	6 Com	G
Hydroelectric	7 Ind	C
CAES	8 Ind	C
Hydrogen	9 Ind	F
	9 Com	F

Thermal storage	10 Res	E
	10 Ind	D
	10 Com	D
Refrigerator storage	11 Ind	E
	11 Com	E
Heat pump	12 Res	B
	12 Ind	B
	12 Com	B
Electric vehicles	13 Ind	F
Thermal coat	14 Res	C
	14 Ind	B
	14 Com	B
Fixtures	15 Res	G
	15 Ind	H
	15 Com	G
Solar screens	16 Res	D
	16 Ind	D
	16 Com	C
District heating	17	G
Heat recovery	18 Com	E
Heat pump	19 Res	E
	19 Ind	C
	19 Com	C
Diffusers	20 Res	F
	20 Ind	C
	20 Com	B
Hydronic appliances	21 Res	C
	21 Com	A
DHW recovery	22 Res	F
	22 Com	D
Circulators	23 Res	H
	23 Com	D
Fans	24 Ind	E
	24 Com	B
LED	25 Res	B
	25 Ind	B
	25 Com	B
Efficient electric motors	26 Ind	C
	26 Com	B
Capacitor bank	27 Ind	E
	27 Com	D
Optimizers	28 Res	D
	28 Ind	B
	28 Com	B
Heating	29	E
Domestic hot water	30	F

Cooling	31	E
Ventilation and Conditioning	32	B
Lighting	33	F
Solar screens	34	F
TBM systems	35	F

Table 10 - Classes of EEMs for Table X

Legend	
Res	residential
Ind	industrial
Com	commercial

The best intervention according to this classification procedure appears to be the conversion of heating from fuel boilers to electric heat pumps. The thermal coat has also proved to be very advantageous while fixtures and sunscreens give poorer results. Subsequently, the intermediate positions are occupied by distributed production plants and interventions on the electrical system. Storage and BACS have poor results, while the heating system is the most articulated one offering advantageous and disadvantageous interventions.

The histograms below show the classes of EEMs in terms of numerical values (in descending order) for each sector analysed:

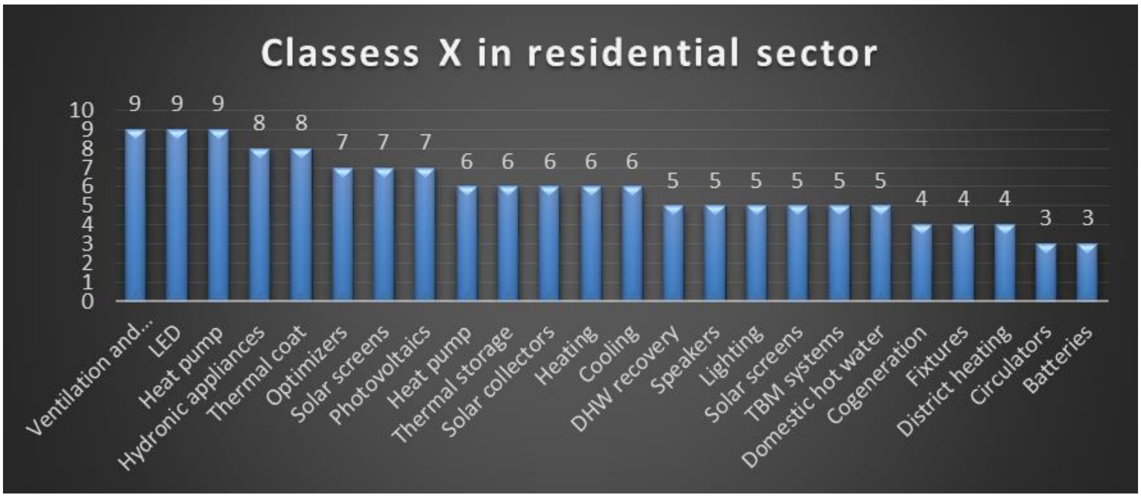


Figure 20 - Classification obtained according to Table X for the most significant EEMs in Residential sector

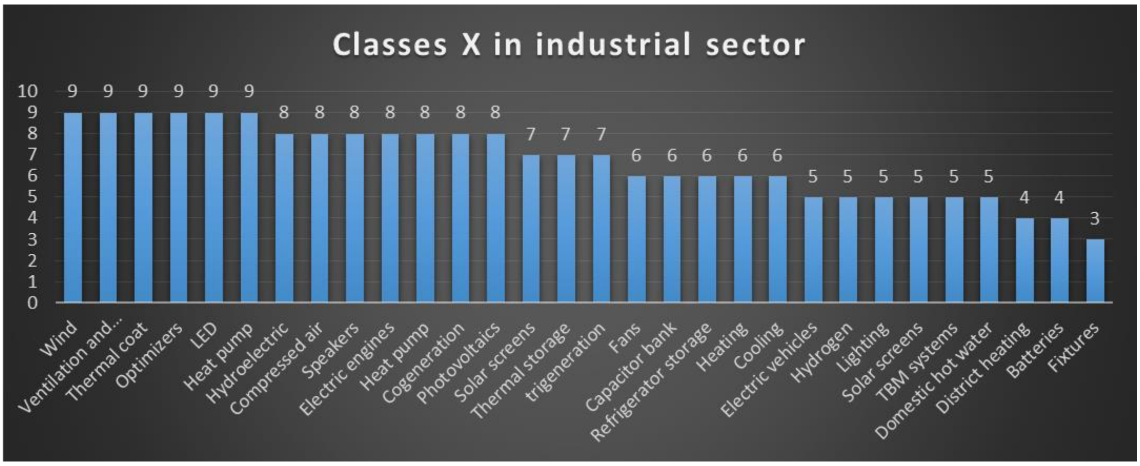


Figure 21 - Classification obtained according to Table X for the most significant EEMs in industrial sector

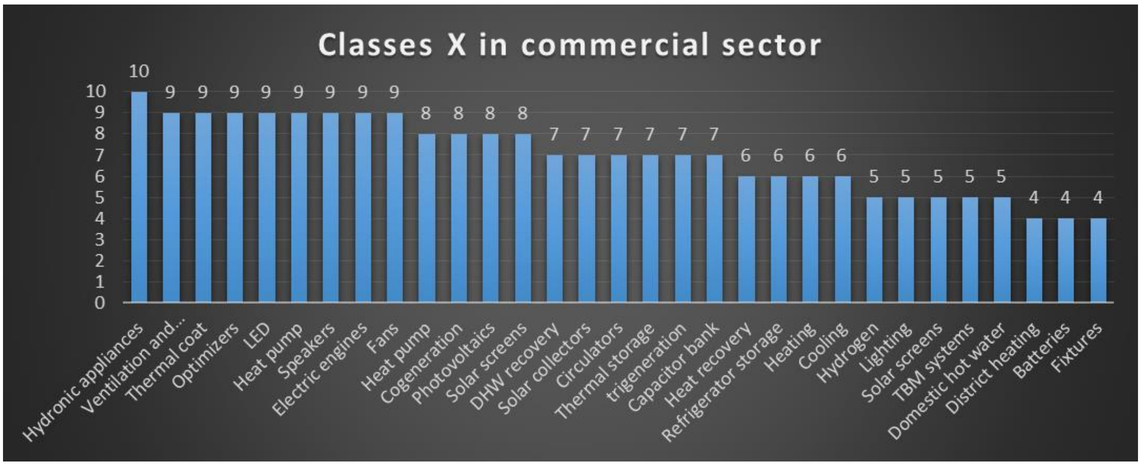


Figure 22 - Classification obtained according to Table X for the most significant EEMs in Commercial sector

Starting from the list of EEMs and their categorization, we defined an evaluation scheme for energy savings of different characteristics and classification of schemes through the classes of EEMs. Combining these tree activities we concluded the first part of this study.

The approach followed for the determination of the classes is detailed described in this report, however for further details on the numerical calculations please refer to the attached and linked spreadsheet file: SENSEI D4.3 Appendix A: classes of EEMs.xls which is an integral part of the deliverable itself**.** Appendix A section helps for understanding the structure of excel file.

3 Stakeholder engagement and consultation

This section aims at presenting the results of the stakeholder engagement and consultation activities. **Section 3.1** explains in detail the reason for the methodological choices on how the sample was built and the findings that have been reached. **Section 3.2** goes into the feedbacks gathered. **Section 3.3** resumes the results and lessons learned.

3.1 The methodological choices

The stakeholder engagement and consultation was focused on validation of the results for Section 2 on the introduction of new concepts and definitions that P4P scheme is based on. The opinions of research and academia experts, EPC facilitators, EE Project developers and providers/integrators of IOT technologies have been gathered and analysed.

To this purpose, **two different methodologies were used: in-person focus groups and interviews by mail.** The choice of integrating these two methodologies allowed to analyze our work in greater depth and discover possible critical issues.

The focus group permits to collect the individual stakeholder opinion and, at the same time, to compare it with others' opinions. This leads an in-depth compared feedback in a collective brainstorming activity. In addition, if particularly interesting unexpected elements emerge, the candidate can also ask the interviewer for additional information. These features of the focus group methodology are even more important in case the surveys are involving industry experts.

Furthermore, we carried out semi-structured interviews by e-mail, in order to reach more interviewees with a multicast approach. This methodology did not require the physical presence and minimized the effort for participating. In fact, with the interviews by mail, more interviewees from different countries / places were able to respond in the times they preferred.

Both methodologies used the same documentation and information (please see Appendix C): same questions were used for both interviews.

3.2 Stakeholder consultation and engagement results

This section analyses the stakeholder consultation findings.

First of all is necessary to specify the terminology used:

- Internal: internal Member of the SENSEI Community;
- External non-member: external Non-Member of the SENSEI Community;
- External member: external already Member of the SENSEI Community.

Semi-structured interviews by email were pursued from 06/07/2020 to 5/08/2020. Table 11 shows the engagement results.

E-mail Interviews		
n° of guests: 9	n° participants: 4	new member: 2
1 internal 3 external non-member 5 external member	1 internal 1 external non-member 2 external member	2 external non-member

Table 11 - Resume of stakeholder consultation process though e-mail interview

The audience invited was: 5 External - Member of the Community (ESCOs, Aggregators, EPC facilitators, EE Project developers),3 External – Non-member of the Community (EPC facilitators)/ 1 Internal(Research and academia).

The audience which attended the interviews was: 2 External - Member of the Community (ESCOs, EPC facilitators), 2 External – Non-member of the Community (EPC facilitators) and 1 Internal (Research and academia).

Two new members joined the SENSEI community.

The Focus group in presence involved an IoT provider Technologies and took place at Omnia Energia headquarters on 17/07/2020. It lasted 1.30h.

Focus Group		
n° of guests: 4	n° participants: 3	new member: 4
4 external non-member	3 external non-member	4 external non-member

Table 12 - Resume of stakeholder consultation process through focus group

Four external members joined the SENSEI community and three of them took part in the interview.

Section 3.2.1 presents the variable that influenced the stakeholders' feedback. The interviewees that took part in the focus group have a more consumer approach. **Section 3.2.2** presents the overview to share and validate the results of first part of this report. **Section 3.2.3** presents the opinion of the interviewees regarding Table A: Qualitative analysis of the effects on the network, on the two parameters: energy and network. **Section 3.2.4** presents the opinion of the interviewees regarding the technical qualitative analysis with details regarding the benefits for the user and comfort aspect. **Section 3.2.5** presents a technical parameter of electric storage system used for EEMs classes. **Section 3.2.6** reports the assessments regarding the concepts of P4P scheme and P4P rates. **Section 3.2.7** summarizes the findings of the consultation and the lessons learned

3.2.1 Variables involved in the sample: a more consumer approach for the focus group participants

The results of the survey are rather homogeneous. No particular differentiation variables emerge in the sample.

The only small differences are given by the different levels of knowledge of the sector that leads the participants in the focus group (all IoT Technology providers) to consider energy efficiency interventions according to a consumer approach.

In fact, all the participants in the focus group judged the energy efficiency interventions considering three different parameters: ease of design and installation, the relationship between price and energy production efficiency, and geographical conditions.

All the participants cited photovoltaics as a preferred intervention for their versatility, for small businesses, for the strength of the sun in the South of Italy, and the cost-effectiveness of the intervention.

> ➔ **Verbatim from the interviews:**
>
> *"The most commercial thought that comes to mind first is photovoltaics, they are more widespread geographically in Southern Italy, because of major solar exposure, the one that reaches everyone and is more commercial; the solar thermal is bigger and not suitable for a small reality like photovoltaic"*

Furthermore, when the participants in the focus group think about energy efficiency, the mental associations lead to think about: environment and environmental sustainability, sustainable zero waste economy and production capacity of the Calabria region.

> ➔ **Verbatim from the interviews:**
>
> *"Self-consumption ... it is true that on the one hand it is important to save energy but it is important to produce for what we need otherwise energy efficiency makes no sense to exist" "Green, Environment" "We are a region that produces more of what we consume "*

The European spread of energy efficiency is seen as differing in terms of distribution in the various states and regions.

This is due to a concomitance between political responsibilities and a lack of environmental awareness / culture among citizens.

> ➔ **Verbatim from the interviews:**
>
> *"The paradox is that compared to some Nordic countries at the political level, the Greens at European level are more established in the North than in the South. They are evidently more widespread because there is more collective consciousness. It is paradoxical because in the South we have all the natural*

resources, the energy of the sun which allows us to produce more. Therefore we need to investigate why we do not have this collective consciousness "; "The role of politics is fundamental, even a greener economy depends on politics, there are countries that started this path earlier, while others are trying to catch up now. This is why there is a difference between countries in Europe".

"The most commercial thought that comes to mind first is photovoltaics, they are more widespread geographically in Southern Italy, because of major solar exposure, the one that reaches everyone and is more commercial; the solar thermal is bigger and not suitable for a small reality like photovoltaic"

The SENSEI project is considered very useful to develop and spread this sensitivity in a more homogeneous way.

3.2.2 The overview to share the results of first part of Deliverable 4.3

It is important to repeat that the stakeholder engagement and consultation has been focused on validation of the results for Section 2 (Classification of the EEMs). At this end, all respondents rated first part of deliverable 4.3 and table 1 positively and completely (table 1 is only a restricted meaning for Table A – grid qualitative analysis. **Please see Appendix C1 for further information on Table 1**).

The interviewees of the focus group do not have a depth technical knowledge of all the EEMs, but only a basic knowledge. They consider also important the type of analysis carried out and also believe that there are no shortcomings in table 1.

Half of the sample pointed out that perhaps the vision of SENSEI might be too focused on the residential side, while many of the interventions examined are very important also at a business level.

One of the stakeholders interviewed by email would consider the addition of a new EEM to the list: the installation of thermostatic valves for centralized heating systems

3.2.3 Table A: Qualitative analysis of the effects on the network - two aspects: energy and network.

Table A (please see Section 2.3.1) is also, overall, judged positively as well as the values assigned to the energy aspect.

The high value for photovoltaics, judged as the most important, is very correct as well as the one for storage batteries.

The stakeholders that took part to the focus group considered that LED lamps and automatic control systems should have a slightly higher value.

The ones interviewed by e-mail, on the other hand, suggested raising the score for: electric vehicles, storage systems and micro wind.

> ➔ **Verbatim from the interviews:**
>
> *"For us, photovoltaics is the one that gains traction so the high score for photovoltaics suits us well, that's correct"; "Even the storage batteries that are related to the use of photovoltaics have a high score and are fine"; "I would have given some more points to the LED lamps"; "The" energy "values are acceptable. It is known that some measures related to ELECTRICAL SYSTEM category, as Electric Engine or Capacitor Bank are not suitable for residential sector. The same analysis could be made for other measure evaluated with "n.a." I think that in the near future the Electric vehicles could become an important asset for EEMs in residential application "; "The values adopted are adequate to rank the different intervention. Also the main categories are well defined according to P4P scope"*

The assessment of the network aspects is clear, consistent and shareable for all interviewees

> ➔ **Verbatim from the interviews:**
>
> *"I completely agree with the values associated to the grid effect and the gap used to differentiate them. This means that the step of 0.2 value from the Load Shifting to the Strategic Conservation is very realistic. Considering that we are moving towards the principle of electrification, the effects on the grid that you*

defined as, "Load Shifting", "Strategic Conservation" and "Peak Clipping" will be the most desired from the energy provider perspective"; "The weights are correctly quantified: while the first two change only the profile with an increase of energy in some strategic hours, the load shifting is energy neutral, the last two implies an energy reduction"

3.2.4 Technical qualitative analysis in detail with benefits for the user - The comfort from the user side

For all interviewees, comfort is considered the fundamental motivation for the choice of energy efficiency interventions, especially in residential areas.

For this reason, the weight of 0.50 is rated to be fairly low.

➔ **Verbatim from the interviews:**

"If I think about my home, the main goal is to improve comfort, if I do something I do it for this. For this reason I would give comfort the highest weight compared to the other parameters taken into consideration"; "In the residential context, comfort prevails over energy savings, so I would give 0.65"; "I guess that scale of values start from 0 to 1, so a value of 0.5 for COMFORT is an intermediate level. Considering the user side the value of 0.5 could be acceptable, but a higher value could strengthen the user role in an energy efficiency interventions list "; "The 0,5 value is at the moment a good trade-off between comfort and costs" "I completely agree with the values associated to the grid effect and the gap used to differentiate them. This means that the step of 0.2 value from the Load Shifting to the Strategic Conservation is very realistic. Considering that we are moving towards the principle of electrification, the effects on the grid that you defined as, "Load Shifting", "Strategic Conservation" and "Peak Clipping" will be the most desired from the energy provider perspective"; "The weights are correctly quantified: while the first two change only the profile with an increase

of energy in some strategic hours, the load shifting is energy neutral, the last two implies an energy reduction"

3.2.5 The characteristics of the electric storage system

All interviewees agreed on the proposed evaluation of the characteristics of the storage system taken into consideration.

In addition, some mentioned other features that have been considered were: the room where the storage is installed, the appropriate sizing, and the optimization of charge / discharge cycles.

3.2.6 The P4P scheme and P4P rates

The P4P scheme concept is considered in a positive way, and was defined as: innovative, correct, winning.

For the interviewees in the focus group, the most positive aspect highlighted was the idea of collaboration between actors at the base of the scheme. Another positive aspect highlighted was the possibility of P4P schemes to create collective awareness.

➔ **Verbatim from the interviews:**

“It is something new"; "He makes a broad argument because it involves everyone in a win-win collaboration concept"; "The idea is interesting because it considers both sides of both energy saving and efficiency. Even more in an increasingly dynamic context in which the customer now only wants the result, this concept of relying on a go-out gives you directly the result is a positive and useful concept "; "In particular, the concept of P4P rates that you explained in SENSEI project, for which energy providers are willing to pay for each kWh saved or moved to another time of the day, could accelerate the much-desired energy transition".

3.3 Conclusions from stakeholder consultation

All the engaged stakeholders have evaluated positively the questions, and considered them to be straightforward. The answers provided by the interviewed stakeholders substantially confirmed the research activity that was carried out.

The name of the stakeholder, the company they belong to and their professionality are listed below:

- Nicola Sorrentino, Assistant Professors, DIMES UNICAL (ITALY)
- Michele Liziero, EPC facilitators, Energy Team SpA (ITALY)
- Luigi Rizzo, Providers and integrators of IOT technologies, AEI Srl (ITALY)
- Regina Drazhi, Providers and integrators of IOT technologies, AEI Srl (ITALY)
- Massimiliano Mazzeo, Providers and integrators of IOT technologies, AEI Srl (ITALY)
- Emilio D'Agostino, Providers and integrators of IOT technologies, AEI Srl (ITALY)
- Francesco Guzzo Cava, EPC facilitator, FGC Ingegneria (ITALIA)
- Giuseppe Spagna, EGE, Studio Tecnico Giuseppe Spagna (ITALIA)

4 Estimating the P4P rates

This section aims at proposing an approach for evaluating P4P rates from the energy provider perspective. **Section 4.1** introduces the concepts of P4P rates and energy provider that are further used in the next sections. **Section 4.2** propose an evaluation approach of P4P rates for complying with energy efficiency obligation schemes in the EU. **Section 4.3** proposes an estimation scheme that energy provider would be willing to offer. For both cases, it is assumed a channelled payment from energy system operator next to the SENSEI business model. **Section 4.4** wraps-up the conclusions**.**

4.1 Basic concepts and definitions: P4P rates and Energy provider

The first part of this section starts with the rollout of some new concepts and definitions that P4P schemes bring with them. In fact one the questions contained in the Stakeholder consultation interview was related to the concept of P4P rates.

Within the SENSEI consortium the following concepts and definitions for P4P rates are being explored:

- *A P4P rate can be seen as funds transferred per energy saved*. The Request for Service for pay-for-performance schemes in the US offers an idea of what they do in the US[39]. However, this will definitely be different in the EU because of the regulatory environment.
- *A P4P rate could be interpreted as a numerical value (€/kWh) that energy providers are willing to pay for each kWh saved or moved to another time of the day.* These rates could vary according to the variations the electricity demand curve (a kWh saved at peak time is worth more than one saved at night / in the valleys).
- *The P4P rates should have the ultimate aim of avoiding network overload* (too much electricity transported at peak times) *and ensure that the demand curve is aligned with that one of renewable energy production*, in order to generate a return economic and

[39] Santini M. , Tzani D,, Thomas S. , Stavrakas, V., Rosenow J., Celestino A. (2020): Experience and lessons learned from pay-for-performance (P4P) pilots for energy efficiency, Deliverable 4.4 SENSEI 2020

environmental return and so allowing utilities to meet energy needs with the maximum percentage of economic and clean energy.

The approach that follows was not focused on quantifying the P4P rates (only simple calculation examples are shown), but on **identifying which variable scan affect these rates, considering the analysis carried out in the classes of EEMs.**

Before proceeding with the P4P rates specification, the concept of the energy provider, as it was used in the proposal, needs to be further explained, considering its role in the SENSEI model.

When talking about energy providers, one or both of the following cases can be assumed:

- A TSO or DSO. The text of the proposal consistently influenced from US pilots, where energy providers act also as system operators or distribution companies supported by public entities too.
- An energy provider or an energy utility that bids to the capacity market, assuming that generation capacity can be supplemented by energy efficiency retrofits for demand reduction.

4.2 P4P rates for complying with EEOs

Energy efficiency obligation schemes (EEOS) have a fundamental importance emerged for the first time in the 1980s, in the United States, where many States required utilities to engage in “Least-Cost Planning” or “Integrated Resource Planning”, in order to procure energy efficiency savings on an equal basis with supply-side resources.

Across the European Union energy efficiency has been supported by dedicated policy instruments providing a combination of financial subsidies and regulatory push.[40] With the adoption of the ‘Efficiency First’ principle, as part of the Clean Energy for All Europeans (CE4ALL) package and its various legislative components, there are now emerging opportunities for

[40] Rosenow, J., Fawcett, T., Eyre, N., Oikonomou, V. (2016): Energy efficiency and the policy mix. Building Research & Information 44(5-6), pp. 562-574

elevating energy efficiency to an energy system resource.[41]The concept of Efficiency First, or E1st is currently being further solidified through research[42] and investment planning decisions.

In principle, energy efficiency has many of the characteristics of supply-side technologies: increasing energy efficiency means providing energy services at the lowest cost; it helps with increasing the security of supply and can alleviate congestion in the grid. There is no fundamental reason why energy efficiency could not (and should not) be rewarded for providing those benefits to the energy system[43][44].

Improving the final energy efficiency is the primary focus of the SENSEI project and this could be addressed through a set of measures as listed in Section 2.2.2

Directive 2012/27/EU requires that each Member State establishes a **mandatory national energy efficiency scheme**. This scheme ensures that energy distributors and/or energy companies (obligated parties) operating on the territory of each Member State achieve a cumulative final energy saving target by 31 December 2020.This objective is at least equivalent to the achievement each year from 1 January 2014 to 31 December 2020, of new savings equal to 1.5%, in volume and of the average annual sales of energy to final customers of all or all energy distributors.

There is now limited experience in Europe with compensating energy efficiency for the value it can bring to the energy system so the question is **how energy efficiency can be rewarded for the value it provides through non-traditional (market) mechanisms**, e.g. dedicated energy efficiency programmes such as the following Energy Efficiency Obligation schemes (EEOs).

EEOS were in place in several Member States before the introduction of the Energy Efficiency Directive. The most successful were those in the UK and Denmark, both of which have been operating for some 20 years. These EEOS have produced greater savings than other EU countries (ENSPOL 2015a) and therefore could be seen as the first runners. However, in both countries, the growing ambition for savings targets and the cost of systems to bill payers have raised

41Pato, Z., Rosenow, J. (2019): Efficiency First in Europe's new electricity market design – how are we doing? In: Proceedings of ECEEE Summer Study 2019

[42] See the Horizon 2020 project enefirst : https://enefirst.eu/reports-findings/

[43]Enefirst (2020) Defining and contextualizing the E1st principle

[44]RosenowJ., Thomas S. (2020): Rewarding energy efficiency for energy system services through markets: opportunities and challenges in Europe

political and public concerns. This has affected the recent reductions in their savings targets. Following the European directive, the number of bond schemes rose from 6 to 15.

Figure 23 shows the EEOS mechanism. It sets a target usually in terms of energy savings that needs to be achieved by energy companies as obligated parties.

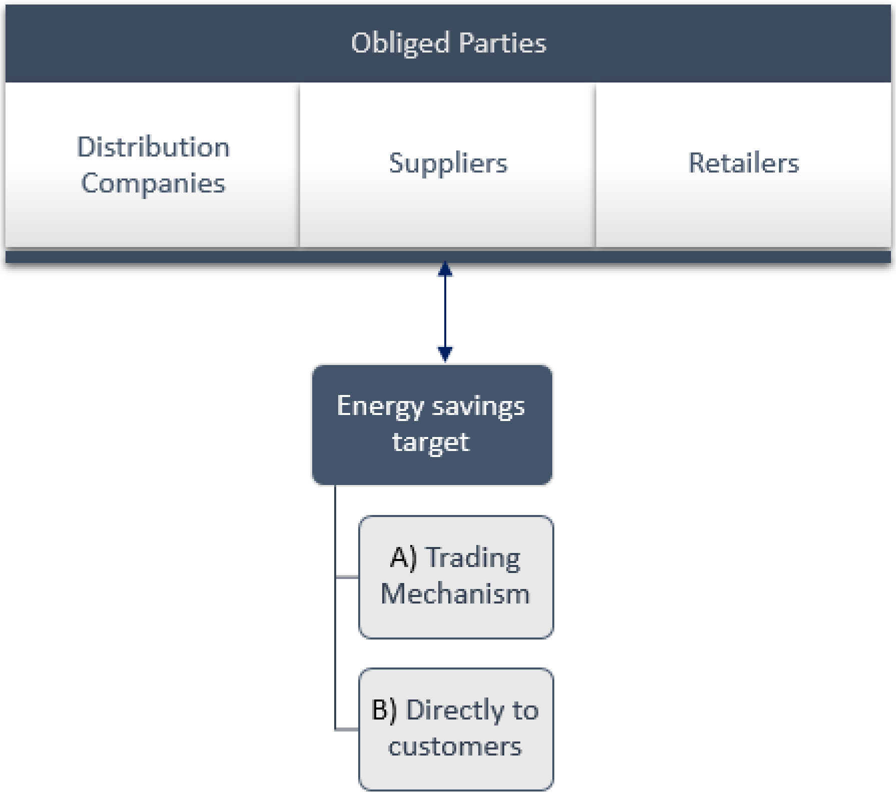


Figure 23 - The mechanism of EEOs

The obligated energy companies can be distribution companies, suppliers and/or retailers. Obligated parties have the freedom to achieve the target set for them through range of means[45]: they can deliver the target through providing energy efficiency measures directly to customers, they can work with intermediaries (trade bodies, municipalities, managing agents) or they can in some circumstances purchase energy savings through a trading mechanism (so-called White Certificates).

Based on the mechanism described in Figure 23 **we suppose that Energy companies could deliver the energy savings target by providing energy efficiency measures directly to customers**. The Energy companies could introduce P4P rates, incentivising the SENSEI model to

[45]Rosenow et al. 2017

implement energy efficiency interventions as an energy system resource. This would lead to larger savings at lower costs, and bring benefits to the overall energy system avoiding capacity, transmission and distribution system costs and enabling greater flexibility in energy consumption.

EEOS were used to provide savings primarily through the improvement of building envelopes, secondly for the early replacement of inefficient equipment and the improvement of industrial processes: it is not casual that these EEMs have been listed in our analysis (Section 2).

Energy savings could come from savings in locations with grid constraints. They could provide savings to low-income households or savings that highly coincide with peak loads on the grid.

In this context (considering the effects of EEMs explained above) in order to evaluate P4P rates for complying with the EEOS, distribution companies could use the classes of EEMs mapped in Table C. **Table C takes into account the technical-economic aspects of the energy efficiency measure** and estimates the costs and savings once a value has been assigned to the TEP value (0.10 €/kWh). The obtained value is supposed variable due to market trends and to the rapid evolution of the electricity system. Therefore **Table C allows to estimate the risk that costs would be greater than savings for each of the specified measures**.

EEM name	EEM ID	Table C Class
Photovoltaics	1 Res	C
	1 Ind	C
	1 Com	C
Wind	2 Ind	B
Solar collectors	3 Res	D
	3 Com	C
Cogeneration	4 Res	F
	4 Ind	B
	4 Com	B
trigeneration	5 Ind	C
	5 Com	C
Batteries	6 Res	I
	6 Ind	I
	6 Com	I
Hydroelectric	7 Ind	B
CAES	8 Ind	B
Hydrogen	9 Ind	E
	9 Com	E
Thermal storage	10 Res	C
	10 Ind	B
	10 Com	B

Refrigerator storage	11 Ind	C
	11 Com	C
Heat pump	12 Res	B
	12 Ind	B
	12 Com	B
Electric vehicles	13 Ind	F
Thermal coat	14 Res	B
	14 Ind	B
	14 Com	B
Fixtures	15 Res	G
	15 Ind	G
	15 Com	G
Solar screens	16 Res	B
	16 Ind	B
	16 Com	B
District heating	17	H
Heat recovery	18 Com	D
Heat pump	19 Res	C
	19 Ind	B
	19 Com	B
Diffusers	20 Res	E
	20 Ind	B
	20 Com	A
Hydronic appliances	21 Res	B
	21 Com	A
DHW recovery	22 Res	E
	22 Com	B
Circulators	23 Res	H
	23 Com	C
Fans	24 Ind	C
	24 Com	A
LED	25 Res	B
	25 Ind	B
	25 Com	B
Efficient electric motors	26 Ind	B
	26 Com	B
Capacitor bank	27 Ind	C
	27 Com	C
Optimizers	28 Res	B
	28 Ind	B
	28 Com	B
Heating	29	D
Domestic hot water	30	G
Cooling	31	E
Ventilation and Conditioning	32	A
Lighting	33	F

Solar screens	34	F
TBM systems	35	F

Table 13- Table C: Classes of EEMS for EEOS

Depending on the classes achieved in Table C the P4P rates level will be indicated in accordance with the Table 14:

Classes of EEMs	P4P rates
A - B	High
C - D	Medium
E - F	Low
G - H	Very Low
I - J	N.A.

Table 14 - P4P rates as a function of class of EEMs

The energy company could be willing to pay a maximum value for each TOE saved.

Considering the value of Table (reported below for simplicity) a P4P rate is estimated for each EEMs.

This financial support into SENSEI business model shall be paid as an annual incentive payment over multiple years.

Following the above analysis, in order to provide an evaluation example of the P4P rates some numerical values are shown below (purely for illustrative purpose, not to be considered as real values).

The value of P4P rates (incentives) to be paid for each intervention could be calculated as follows:

$$I = V_{max} * \left[\frac{class\ value}{\mathrm{MAX}(class\ value)}\right] * TOE$$

Where:

- V_{max} is a maximum payment expressed in [€ / TOE];
- $class\ value$ is the numerical value correspond to the classification in the considered Table

(Table C in the case of EEOS);

- MAX $class\ value$ is the maximum value of the classification we used (at today A=10).It is used for normalisation purpose in the formula.

Class (Value)	Class (Alphabetical)
10	A
9	B
8	C
7	D
6	E
5	F
4	G
3	H
2	I
1	J

Table 15 - Mapping the class of the EEMs with the corresponding numerical value

- TOE (tonne of oil equivalent) is the energy saved in *TOE* calculated through the formula indicated in Table C and mapped for each EEM in Table 7.

Example Calculation:

Considering a replacement of electric motors and a replacement of a heat pump in for residential use and assuming a maximum payment of 0.15 € / TOE.

In case of an electric motor (Power=300 kW) there is a saving of 269 TOE and the corresponding class in Table C is equal to B (numerical value=9), therefore the incentive that receives the intervention will be calculated as follow:

$$I = V_{max} * \left[\frac{class\ value}{MAX(class\ value)}\right] * TOE = 0.15 * (\frac{9}{10}) * 269 = 36{,}31\ €$$

In case of heat pump (power= 20 kW) there is a saving of 47 TOE and the corresponding class in Table C is equal to B (numerical value=9), therefore the incentive that receives the intervention will be calculated as follow:

$$I = V_{max} * \left[\frac{class\ value}{MAX(class\ value)}\right] * TOE * TOE = 0.15 * (\frac{9}{10}) * 47 = 6{,}34\ €$$

Therefore we can suppose that energy companies, as obligated parties for achieving the energy savings target, are willing to pay these P4P rates (funds) in order to realize an energy efficiency intervention of electric motor rather than implement an heat pump(supposing a residential case study).

4.3 The Energy provider perspective

The definitions reported in section 4.1 are preparatory also for the section in question.

In section 4.2 the role of distribution companies (as obliged parties) is crucial for delivering energy savings target (in EEOs mechanism) through providing energy efficiency measures directly to customers.

The same concept applies to the TSO which assumes the role of energy provider when evaluating P4P rates at transmission system operator level.

TSOs have a role of great importance in the overall grid system: it guarantees the continuity and the stability of the electricity services. To do this, it carries out maintenance and network upgrade interventions, regarding both the transmissible power along a line, and network security and reliability.

The energy efficiency transition certainly passes through a careful development of the transmission network, aimed at reducing operating losses. The development of power grids is also crucial for promoting diffusion of industrial cycles for energy recovery and market penetration of electricity in industrial and mobility sectors. In fact, the electricity grid represents the enabling infrastructure for large-scale deployment of electric vehicles (the reason why EVs were listed in the EEMs).

The SENSEI project through the role of the aggregator could turn to the TSO to receive an incentive following the implementation of energy efficiency interventions that bring benefits to the grid. Please see Figure 24 showing the P4P rate concept in the value chain of the SENSEI business model. An agreement is established between an ESCO and an aggregator of energy efficiency projects. The aggregator creates portfolios of projects, offers the time- and location-specific power consumption changes from the EEMs to TSO with a mandate to support energy efficiency.

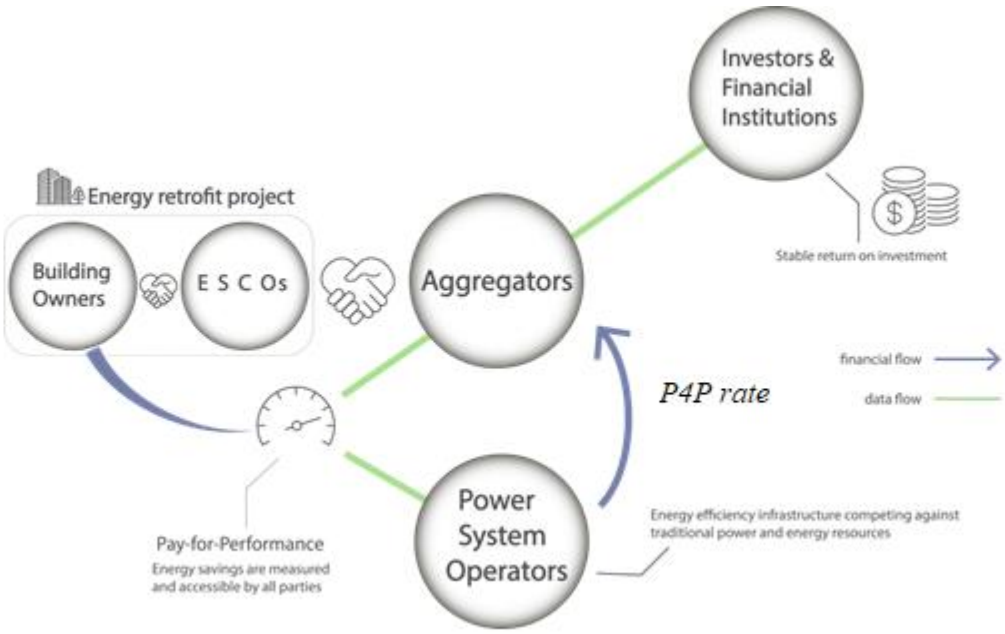


Figure 24 - The energy efficiency value chain of the SENSEI business model and the integration of P4P rate

The 2020 Development Plan of Italian TSO [46] (TERNA) sits in a complex and challenging context, characterised by:

- Transition to a new zero-emissions energy system based on renewables. We are at a crucial stage for the future of the 2015 Paris Agreement, and the goals of COP 21 must now be transformed into real actions. The “Integrated National Energy and Climate Plan”, published by the Italian Ministry for Economic Development and sent to the European Commission, supports this.
- A changing climate context, together with an increase in the frequency and intensity of extreme meteorological phenomena.

The transition of the electricity system towards complete decarbonisation requires activation of all necessary levers for the full integration of renewable production in order to reduce emissions on a long-term basis.

On the other hand, the development of renewable energy arises various difficulties for the grid: higher uncertainty in the energy production forecast, fewer grid stabilization services, etc. With a focus on the Italian nation, a relatively recent phenomenon that has been observed is the increase in the hours of saturation of energy transmitted between different areas of the territory; in particular, the wind farms concentrated in Southern Italy in moments of increased production do not allow the transit of all the energy to the Northern Italy area, so the power fed into the grid by these farms has to be curtailed.

Through energy efficiency interventions, with subsequent reduction in demand, it is possible for the TSO to reduce the number of interruptible customers and in some specific cases to not carry out network adaptation interventions; furthermore, after a certain reduction in the residual load required during the year, traditional power plants can be decommissioned; on the other hand the reliability of the grid will be reduced as the static conversion units of renewable plants do not provide grid services.

For the above reasons, TERNA incorporates in its strategic planning the aim of a de-carbonised economy through an energy transition based on the integration of renewable sources, energy efficiency and storage system.

[46] https://www.terna.it/it/sistema-elettrico/rete/piano-sviluppo-rete

At this end, the TSO may have an interest in financing EEMs and could support the SENSEI model with economic incentives (P4P rates) defining a maximum value to pay.

In order to support the TSO development plan drivers, the decarbonisation goals particularly (on both an international and national level thanks to the intrinsic energy efficiency needs) the EEMs as evaluated in table is the best fit.

The calculation of the TABLE X values contains all the types of evaluation carried out in section 2.3 (integrates the evaluations of Tables A, B and C). For simplicity it could report the meanings of 3 tables:

1. Table A: Grid effects.
2. Table B: Building benefits.
3. Table C: Value of measures.

In particular, **Table A** contains a qualitative analysis of the effects on the grid; **Table B** explains a technical qualitative analysis with details of users' benefits; **Table C** shows a quantitative analysis.

The classes of EEMs resulting from Table X are shown below:

EEMs name	EEM ID	Class
Photovoltaics	1 Res	D
	1 Ind	C
	1 Com	C
Wind	2 Ind	B
Solar collectors	3 Res	E
	3 Com	D
Cogeneration	4 Res	G
	4 Ind	C
	4 Com	C
trigeneration	5 Ind	D
	5 Com	D
Batteries	6 Res	H
	6 Ind	G
	6 Com	G
Hydroelectric	7 Ind	C
CAES	8 Ind	C
Hydrogen	9 Ind	F
	9 Com	F
Thermal storage	10 Res	E

	10 Ind	D
	10 Com	D
Refrigerator storage	11 Ind	E
	11 Com	E
Heat pump	12 Res	B
	12 Ind	B
	12 Com	B
Electric vehicles	13 Ind	F
Thermal coat	14 Res	C
	14 Ind	B
	14 Com	B
Fixtures	15 Res	G
	15 Ind	H
	15 Com	G
Solar screens	16 Res	D
	16 Ind	D
	16 Com	C
District heating	17	G
Heat recovery	18 Com	E
Heat pump	19 Res	E
	19 Ind	C
	19 Com	C
Diffusers	20 Res	F
	20 Ind	C
	20 Com	B
Hydronic appliances	21 Res	C
	21 Com	A
DHW recovery	22 Res	F
	22 Com	D
Circulators	23 Res	H
	23 Com	D
Fans	24 Ind	E
	24 Com	B
LED	25 Res	B
	25 Ind	B
	25 Com	B
Efficient electric motors	26 Ind	C
	26 Com	B
Capacitor bank	27 Ind	E
	27 Com	D
Optimizers	28 Res	D
	28 Ind	B
	28 Com	B
Heating	29	E
Domestic hot water	30	F
Cooling	31	E

Ventilation and Conditioning	32	B
Lighting	33	F
Solar screens	34	F
TBM systems	35	F

Table 16–TABLE X: classed of EEMS from the energy provider perspective

Depending on the class value of table X, the P4P rates level will be defined in accordance with Table 14. **An energy provider could set a higher value for P4P rates the greater is the class of the EEMs**.

The proposed approach suggest a higher value for greater class. In simple words, greater class for EEMs means higher reliability, more efficiency, less risk. There is no difference between behind or beyond the meter. Setting a price per kWh saved is a simpler approach that should be evaluated depending by other parameter (i.e. location, nominal power installed, energy conversion efficiency then the technology used and so on)

The energy provider could be willing to offer the P4P rate as a payment flows into SENSEI business model.

The energy provider could be willing to pay a maximum value for each TOE saved and considering the value of Table X (reported above for simplicity) a P4P rate is estimated for each EEMs.

Following the analysis carried out for EEOs, in order to provide an evaluation example of the P4P rates numerical values are shown below (purely for illustrative purpose, not to be considered as real values).

Example Calculation:

Considering a district heating intervention and the introduction of CHP system for industrial use. Assuming a maximum payment of 0.010 € / TOE that energy provider is willing to offer. Also in this case we consider the mapping table Table 15.

In the case of district heating there is a saving of 28 TOE and the corresponding class in Table X is equal to G (numerical value=4), MAX (class value) =10, therefore the incentive that receives the intervention will be calculated as follow:

$$I = V_{max} * \left[\frac{class\ value}{MAX(class\ value)}\right] * TOE = 0.10 * (\frac{4}{10}) * 28 = \ 1.12\ €$$

In case of CHP system in industrial sector there is a saving of 73TOEso the corresponding class in Table X is equal to C (numerical value=8). Therefore the incentive that receives the intervention will be calculated as follow:

$$I = V_{max} * \left[\frac{class\ value}{MAX(class\ value)}\right] * TOE = 0.10 * (\frac{8}{10}) * 73 = 5.84\ €$$

We can suppose that the energy provider is willing to offer the above numerical P4P rates in order to realize an energy efficiency intervention of CHP than implement a district heating in industrial case study.

The same calculation exercise could be made for all EEMs presented in our list, but is important to highlight the main goal and sense of the proposed approach: the higher the class of EEMs value the greater the P4P rate that energy provider could be willing to offer

4.4 Conclusions on estimating P4P rates

Starting from the EEMs classification schemes, Section 4 proposed an approach to estimate the P4P rates that Energy providers would be willing to offer according to different strategies for complying with energy efficiency obligations and different energy market conditions.

In the D4.4 "Experience and lessons learned from P4P pilots for energy efficiency" have been identified some entities in charge of channelling the payments to the entity who is tasked with delivering the performance: public authority, utility or another entity.

In particular, Section 4 of this report highlighted the role of the "other entities", the energy providers, identified as TSO and DSO. These entities could be willing to offer a P4P rate in the SENSEI value chain basing on their proper needs and their development plans.

In particular, we supposed that Energy companies, as obliged parties, could deliver the energy savings target by providing energy efficiency measures directly to customers. The DSO (or obliged energy companies) could introduce P4P rates, incentivising the SENSEI model to implement energy efficiency interventions as an energy system resource.

On the TSO side, the transition of the electricity system towards complete decarbonisation requires the full integration of EEMs in order to reduce emissions on a long-term basis. The TSO will have a certainly interest delivering EEMs because they provide value to the energy systems in many ways: reducing energy costs, avoiding the need for costly capacity, lowering carbon emissions enabling environmental standards to be met more cheaply, avoiding the need for costly network upgrades and allowing heating and cooling system to be used more flexibly. These needs have also emerged from the D4.1 "Rewarding energy efficiency for energy system services through markets: Opportunities and challenges in Europe".

Therefore **the aggregator would receive an incentive from the TSO following the implementation of energy efficiency interventions bring benefits to the grid**.

Section 4 focused the research activities on two different approaches which compensate the energy efficiency for the value it can bring to the energy system, considering the energy provider (in terms of Tso and DSO) perspectives. It tried to propose some discussion points on how energy efficiency can be rewarded for the value it provides through non-traditional (market) mechanisms, in the EEOs mechanism especially.

The devised approaches proposed an up-front, non-performance based incentive in addition to the performance-based payments, as some experiences of P4P schemes outside the EU already made.

5 References

1. https://bcl.nrel.gov/nrel/types/measure
2. https://buildingsync.net/schema/v1.0/datadictionary/
3. https://www.aceee.org/files/proceedings/2015/data/papers/5-91.pdf
4. https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568361/EPRS_BRI(2015)568361_EN.pdf
5. https://blog.aurorasolar.com/how-a-photovoltaic-system-produces-electricity/
6. https://www.energy.gov/eere/wind/how-do-wind-turbines-work
7. https://ec.europa.eu/energy/intelligent/projects/sites/ieeprojects/files/projects/documents/solco_training_solar_collectors_en.pdf
8. https://www.researchgate.net/publication/328344774_Review_of_cogeneration_and_trigeneration_systems
9. https://www.researchgate.net/publication/328344774_Review_of_cogeneration_and_trigeneration_systems
10. https://www.irena.org/costs/Electricity-Storage
11. https://www.energy.gov/eere/water/pumped-storage-hydropower
12. https://www.ctc-n.org/technologies/compressed-air-energy-storage-caes
13. https://americanhistory.si.edu/fuelcells/basics.htm
14. https://www.irena.org/publications/2013/Jan/Thermal-energy-storage
15. https://www.energydepot.com/RPUcom/library/HVAC015.asp
16. https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2013/08/BolesLectureNotesThermodynamicsChapter10.pdf
17. https://www.cars.com/electric-cars/
18. https://www.designingbuildings.co.uk/wiki/Thermal_insulation_for_buildings
19. https://uk.saint-gobain-building-glass.com/en-gb/glass-and-thermal-insulation
20. https://insolroll.com/how-solar-screen-shades-work/
21. https://www.frontiersin.org/articles/10.3389/fbuil.2016.00022/full
22. http://www.thermopedia.com/content/832/
23. https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2013/08/BolesLectureNotesThermodynamicsChapter10.pdf
24. http://www.airvent.com/ventilation-resources
25. http://www.healthyheating.com/Heat-Terminal-Units/Heat-terminal-units.htm#.XtDOejozYYw
26. https://www.thegreenage.co.uk/tech/waste-water-heat-recovery-systems/

27. http://www.watergas.it/grk_files/uploads/grundfos_pompe_italia/news/grundfos_partecipa_alla_fiera_/downloads/hvac_oem_ish__newsletter_2017b.pdf
28. https://en.wikipedia.org/wiki/LED_lamphttps://en.wikipedia.org/wiki/LED_lamp
29. https://www.explainthatstuff.com/electricmotors.html
30. https://electrical.theiet.org/media/1687/power-factor-correction-pfc.pdf
31. https://www.analog.com/en/technical-articles/how-voltage-regulator-works.html#
32. http://www.altecon.it/highlights/en-15232
33. Rosenow, J., Fawcett, T., Eyre, N., Oikonomou, V. (2016): Energy efficiency and the policy mix. Building Research & Information 44(5-6), pp. 562-574
34. Pato, Z., Rosenow, J. (2019): Efficiency First in Europe's new electricity market design – how are we doing? In: Proceedings of ECEEE Summer Study 2019
35. Rosenow J., Thomas S. (2020): Rewarding energy efficiency for energy system services through markets: opportunities and challenges in Europe
36. Rosenow et al. 2017
37. https://www.terna.it/it/sistema-elettrico/rete/piano-sviluppo-rete
38. https://sdgs.un.org/goals

Appendix A - Classes of EEMs

Please refer to the attached and linked spreadsheet file: SENSEI D4.3 Appendix A: classes of EEMs.xls

A1 - EEMs List

A2 - Table A Qualitative network

A3 - Table A Residential detail

A4 - Table A Industrial detail

A5 - Table A Commercial detail

A6 - Table B Qualitative technical

A7 - Table B Residential detail

A8 - Table B Industrial detail

A9 - Table B Commercial detail

A10 - Table C Quantitative analysis

A11 - Table C Residential detail

A12 - Table C Industrial detail

A13 - Table C Commercial detail

A14 - Table X Classes of EEMs

A15 - Table X Residential detail

A16 - Table X Industrial detail

A17 - Table X Commercial detail

Appendix B – Formulary

TABLE A

$$ValueA = (Energy + Conversion) * Grid\ benefit$$

$$Class\ Table\ A = INT\left(\frac{ValueA * 10}{MAX(ValueA)} + 0{,}5\right)$$

- ***Energy***: this value will be as high as the useful energy expected from the intervention, electricity is considered to have a higher value than thermal energy (values from 1 to 5)
- ***Conversion***: valid only for the category in which the energy carrier is replaced (values from 1 to 5)
- ***Grid Benefit***: the effects on the grid described in Figure 8 will have the values shown in the table:

0.7	Strategic Load Grow
0.8	Valley Filling
1	Load Shifting
1.2	Strategic Conservation
1.3	Peak Clipping

TABLE B

- Positive terms:
  - *Benefit*: amount of useful energy, Weight (W_b)=1
  - *Duration*: proportional to the useful life of the intervention, Weight (W_d)=0.75
  - *End of life benefit*: ratio between the benefit at the end of life and at the beginning of life, Weight (W_{EoL})=0.75
  - *Innovation*: new technology with low market penetration, Weight (W_i)=0.5
  - *Comfort*: variation of comfort felt by the users following the intervention (rating 3 corresponds to variation 0),Weight (W_c)=0.5
- Negative terms:

- *Investment*: specific cost of the intervention, Weight (W_{Inv})=0.75
- *Measure*: difficulty and costs in verifying the savings following the intervention, Weight (W_m)=0.75
- *Risk*: probability that the intervention does not lead to benefits at the end of its useful life, Weight (W_r)=0.5

$$Value\ B = (Benefit * W_b + Duration * W_d + EoL\ benefit * W_{EoL} + Innovation * W_i + Comfort * W_c) - (Investment * W_{Inv} + Measure * W_m + Risk * W_r)$$

Once the value B is obtained, it is possible to evaluate the classification of table B:

$$Class\ Table\ B = INT\left(\frac{ValueB * 10}{MAX(ValueB)} + 0{,}5\right)$$

TABLE C

EEM ID	Calculation of Energy - TEP
1,2	$P * Pr * n * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
3	$S * Pr * n * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
4,5	$P * h_{eq} * n * \left(1 - \frac{dec}{2}\right) * (eff - 1) * \frac{1}{f}$
6-11	$C * cycles * \eta_c * \left(1 - \frac{dec}{2}\right) * \frac{1}{f}$
12	$P * h_{eq} * n * (eff - 2) * \frac{1}{f}$
13	$N * con * (eff - 2) * \frac{1}{f}$
14-16	$S * sav * n * \frac{1}{f}$
17,29-35	$S * n * Fabb * (eff - 1) * \frac{1}{f}$
18-21,23-28	$P * h_{eq} * n * (eff - 1) * \frac{1}{f}$
22	$N * n * con * (eff - 1) * \frac{1}{f}$

$$Investment = Initial\ investment + Maintenance * Duration + Measuremen$$

$$Margin = Energy * cost_{energy} - Investment$$

$$Risk = Probability\ (Margin < 0)\ as\ a\ function\ of\ the\ risk$$

- Power [P]: nominal power of the installed plant or machine [kW];
- Capacity [C]: energy accumulated by the system [kWh];

- Units [N]: number of pieces that can be purchased [-];
- Surface [S]: extension of the intervention [m2];
- Duration [n]: physical life of the intervention [years];
- Producibility [Pr]: specific energy produced by the system [kWh / kW * year or kWh / m2 * year];
- Annual equivalent hours [h_{eq}]: full-scale operation equivalent to actual operation [h / year]
- Cycles [cycles]: number of charge and discharge cycles that the storage systems can carry out [-];
- Cyclic efficiency [η_c]: efficiency which includes the conversion and storage of energy [%];
- Decay [dec]: loss of producibility / efficiency at the end of its useful life [%];
- Consumption [con]: energy used by the machine over its useful life [kWh / unit];
- Requirements [Fabb]: average annual specific energy consumption of buildings [kWh / m2];
- Savings [sav]: containment of heat energy losses [kWh / m2 * year];
- Efficiency [eff]: ratio between energy consumption in ANTE and POST situations [-];
- Conversion factor [f]: factor that binds the thermal electric kWh to the TEP [kWh / TEP];
- Energy saving [E]: energy saved thanks to the intervention for the whole life span [TEP];
- Maintenance [main]: maintenance costs [€ / year];
- Measure [meas]: cost to measure the actual savings [€];
- Investment [I]: sum of the various cost items [€];
- Energy value [c_e]: money value of the useful energy [€/TEP]
- Margin [m]: monetary value of the energy efficiency intervention [€];

TABLE X

$$ValueX = \frac{ValueA + ValueB}{2} + 12 * LOG\left(\frac{1}{\sqrt{Risk}}\right)$$

Appendix C – Interview and focus-group questionnaires

C1 - Interview for energy efficiency experts

In The task 4.3 of SENSEI project we developed of an evaluation scheme for energy savings of different EEMs (Energy Efficiency Measure)so called classes of EEMs. We carried out qualitative and quantitative analysis before classes' definition.

In collaboration with other partners we analyzed and evaluated the same intervention for 3 sectors:

a) Residential

b) Industrial

c) Commercial

Table 3 (table 1) shows a full list of energy efficiency interventions, they have been grouped by category and it has been assigned a progressive number.

To differentiate the three sectors, the letters a, b and c have been associated respectively. The combination of a number with one of the letters determines a unique identification code (ID): for example, intervention *1a* will be the installation of a photovoltaic system in the residential sector.

CATEGORY	N	INTERVENTION	Res	Ind	Com
DISTRIBUTED GENERATION	1	Photovoltaics	X	X	X
	2	Wind		X	
	3	Solar collectors	X		X
	4	Cogeneration	X	X	X
	5	trigeneration		X	X
STORAGE SYSTEMS	6	Batteries	X	X	X
	7	Hydroelectric		X	
	8	Compressed air		X	
	9	Hydrogen		X	X
	10	Thermal storage	X	X	X
	11	Refrigerator storage		X	X
	12	Heat pump	X	X	X

CONVERSION OF THE ENERGY CARRIER	13	Electric vehicles		X	
BUILDING ENVELOPE	14	Thermal coat	X	X	X
	15	Fixtures	X	X	X
	16	Solar screens	X	X	X
THERMAL SYSTEMS	17	District heating	X		
	18	Heat recovery		X	X
	19	Heat pump	X	X	X
	20	Diffusers	X	X	X
	21	Hydronic appliances	X		X
	22	DHW recovery	X		X
	23	Circulators	X		X
	24	Fans		X	X
ELECTRICAL SYSTEMS	25	LED	X	X	X
	26	Electric engines		X	X
	27	Capacitor bank		X	X
	28	Optimizers	X	X	X
BUILDING AND AUTOMATION CONTROL SYSTEMS	29	Heating	X	XX	
	30	Domestic hot water	X	XX	
	31	Cooling	X	XX	
	32	Ventilation and Conditioning	X	XX	
	33	Lighting	X	XX	
	34	Solar screens	X	XX	
	35	TBM systems	X	XX	

Table 1 - List of EEMs for several sectors

Legend
kWhe saved
kWht saved

The outcome of our work that is the classification of schemes of EEMS results from the definition of 3 tables and their integration. We devised 3 different tables, each of which conducts an independent analysis, in order to evaluate the EEMs:

1. Table A: Qualitative analysis of the effects on the grid

2. Table B: Technical qualitative analysis with details of the benefits for the user

3. Table C: quantitative table

At the end of each analysis a class of goodness is resulting for each EEM, from the higher value (A class, value 10) to the lower (J class, value 1).

10	A
9	B
8	C
7	D
6	E
5	F
4	G
3	H
2	I
1	J

The numerical correspondance between the class of EEMs and the value associated

A final evaluation that takes into account the classifications obtained in the various tables is described in a further table X not covered by this discussion.

Questions:

1) Considering the application in the 3 sectors Residential, Industrial and Commercial the above list The list of EEMs is complete in your opinion? Or would you add other measures?

2) Table A (*Qualitative analysis of the effects on the grid*), provides a summary analysis of the quality of the intervention, all technical aspects are considered jointly to leave room for the effect that the intervention has on the electricity grid. Table A contains 3 parameters for determining the class of evaluation: ***Energy, Conversion, Network.***

- ***Energy***: this value will be as high as the useful energy expected from the intervention, electricity is considered to have a higher value than thermal energy (values from 1 to 5). For residential sector we used following values for energy:

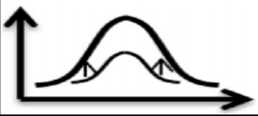
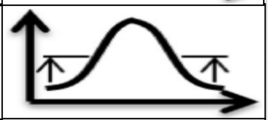
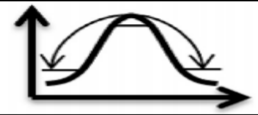
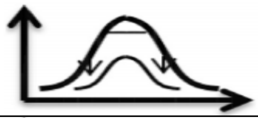
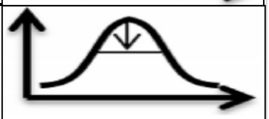
CATEGORY	N	INTERVENTION	Energy
DISTRIBUTED GENERATION	1	Photovoltaics	4
	2	Wind	n.a.
	3	Solar collectors	3
	4	Cogeneration	3
	5	trigeneration	n.a.
STORAGE SYSTEMS	6	Batteries	3
	7	Hydroelectric	n.a.
	8	Compressed air	n.a.
	9	Hydrogen	n.a.
	10	Thermal storage	3
	11	Refrigerator storage	n.a.
CONVERSION OF THE ENERGY CARRIER	12	Heat pump	3
	13	Electric vehicles	n.a.
BUILDING ENVELOPE	14	Thermal coat	3
	15	Fixtures	3
	16	Solar screens	3
THERMAL SYSTEMS	17	District heating	4
	18	Heat recovery	n.a.
	19	Heat pump	2
	20	Speakers	2
	21	Hydronic appliances	3
	22	DHW recovery	3
	23	Circulators	2
	24	Fans	n.a.
ELECTRICAL SYSTEMS	25	LED	3
	26	Electric engines	n.a.
	27	Capacitor bank	n.a.
	28	Optimizers	3
	29	Heating	2

BUILDING and AUTOMATION CONTROL SYSTEMS	**30**	**Domestic hot water**	**2**
	31	**Cooling**	**2**
	32	**Ventilation and Conditioning**	**3**
	33	**Lighting**	**3**
	34	**Solar screens**	**2**
	35	**TBM systems**	**2**

Table A - Qualitative analysis of the effects on the grid,

Do you agree or could you propose other values? Please give reasons for your reply and, if appropriate, provide examples.

- ***Network***: the effects on the grid described in Figure 8:

Effect on the grid	Value	Graphical view
Strategic Load Grow	0,7	
Valley Filling	0,8	
Load Shifting	1	
Strategic Conservation	1,2	
Peak Clipping	1,3	

Network - the values associated to the grid effect

Do you agree or could you propose other values? Please give reasons for your reply and, if appropriate, provide examples.

3) For each parameters of Table B (Technical qualitative analysis with details of the benefits for the user), we associated a weight of 0.5 for COMFORT by user side. Do you agree with this value or could be more correct to increase it? **Please give reasons for your reply and, if appropriate, provide examples.**

4) There are many features of a battery storage system that we used for the classification of battery energy storage system (BESS). In particular, Is it right to consider the useful energy of a storage system in relation to the number of full charge/discharge cycles during the lifetime of the storage system? **Please give reasons for your reply and, if appropriate, provide examples.**

5) In SENSEI project, we use the concept of P4P scheme already applied in US. The P4P scheme brings with it the concept of P4P rates, that is currently being elaborated.
A P4P rate could be interpreted as a numerical value (€/kWh) that energy providers are willing to pay for each kWh saved or moved to another time of the day. These rates could vary according to the variations the electricity demand curve (a kWh saved at peak time is worth more than one saved at night / in the valleys).

The P4P these rates should have the ultimate aim of: avoiding network overload (too much electricity transported at peak times) and ensuring that the demand curve will be aligned with that of renewable energy production, in order to generate a return economic and 'environmental', allowing utilities to meet energy needs with the maximum percentage of economic and clean energy.

What’s your opinion on this concept? Please give reasons for your reply and, if appropriate, provide examples.

Thanks for your time.

- We ask you one last little help: “Was this questionnaire easy to follow and were the questions clearly formulated? If no, why?”;

C2 - Focus Group Guidelines

Supplies

- Note paper
- Pens
- Nametags

Introduction (5 min)

Welcome and thank you for your time today.

My name is CAMILLA FILICE and I will be running the focus group. I work at OMNIA ENERGIA which is one of the partners of the SENSEI project.

I also have my colleague ARTURO LAPIETRA sitting with me. He will be taking notes during the session and may occasionally jump in with some questions.

Please take a moment to review and sign the consent form.

[*ENSURE ALL FORMS ARE SIGNED BEFORE CONTINUING*]

I/my assistant will be tape recording our session so we can transcribe the things we discuss. I will send the minutes/transcription to you after this session so you will have opportunity to review it. Please be assured that I will keep your information secure and your name will not be included in the report.

This focus group will take approximately an hour to one and a half hour of your time.

The purpose of research is to test/gather feedback on "C*lassification of energy efficiency interventions for P4P schemes*". We need your input and want you to share your honest and open thoughts with us.

Before we begin, I would like to give you a quick run-down of how the session will go.

First, we will begin with a few introductions: I will provide you with an overview of the SENSEI project, and I will set some ground rules.

Firstofallwewill introduce youthe SENSEI project. Secondlywewillpresentourwork "classificationofenergyefficiencyfor P4P schemes" whichisthematterofdiscussionofthisfocusgroup. Wewillfirstlypresentthe targets ofthisproject and a general abstract, so as togiveyou a complete pictureofthesituationto be abletoanalyse and judgethedifferentdetailsofourwork. After havingdiscussedaboutthework in general, wewillanalyze and talkaboutwhich are forusthemostsignificantintermediatesteps and forwhichyourfeedbackisimportant.

In particular:

- *We will evaluate the list of energy interventions classified according to 3 sectors*
- *We will retrace and discuss the results of the qualitative analysis relating the effects on the network*

- *We will evaluate the results of the technical qualitative analysis focusing on the details of the benefits for the user*
- *Wewill define thetechnicalcharacteristicsoftheelectricstoragesystemusedtoclassifytherelatedenergyefficiencyinterventions*
- *Wewilltalkaboutthe concept of P4P rateswithintheschemes P4P*

Toanalzyze/discussaboutthesetopics I willpresentsome material/explanatorysheets and wewillmake a series oftests so as to be abletospeak as freely as possible

If you have any questions during the process, please feel free to ask. I might not always be able to answer them, as I do not want to bias your responses, however, I will try to answer them at the end.

Any questions before we begin?

Warm up (10min)

Moderator introduces themselves.
Ask each participant to introduce him/herself.
Name and working position. Knowledge about energy theme.

Warm up question:Whatisyourpreferredrenewableenergyproductionsystem?Answerinstinctivelywithoutthinkingrationally…. The oneyoufeelclosesttoyou….

SENSEI project intro (2min)
General project and goals summary.
Ground rules (2min)
We encourage respectful discussion and debate. Different opinions are welcome.

Please listen to the instructions/questions carefully. There will be times when I will ask you to perform tasks independently and when I want discuss things as a group. If you have questions, please ask.

Please participate in the discussion as much as possible. I am always interested to hear when you agree or disagree with someone. Whenever you wish to ask a question or comment, please raise your hand, so we do not speak all at the same time and clearly understand each other.

Let us try to keep the conversation balanced. Let us make sure everyone has a chance to share their opinion.

Remember, today we are testing/exploring the*classification of energy efficiency interventions for P4P schemes* not you. If you find something confusing or frustrating please let me know. There are no wrong answers.

Session
1.1 The concept of ***ENERGY EFFICIENCY*** (5 min)

Firstly let's make a kind of game: If I say ENERGY EFFICIENCY what comes to your mind? What are the first words, but also the colors, the images, the emotions that come to your mind? Answer instinctively, without thinking, everything that comes to your mind (Collect all the answers around the table by writing them on a billboard trying to push everyone to participate with more inputs. Then review the total picture with the participants and try to define with them what type of scenario is outlined. So for this group the concept of Energy Efficiency is linked to aspects related to .... Etc)

Nowlet'sstarttalking more rationally: in youropinion, to date, howisthesituation in Europewithregardtoenergyefficiency ... (round table debate -geteveryoneinvolved. Encouragetoevaluateeachother's ideas)

2.1 TASK 4.3 (10 min)

Presentation of the abstract of the deliverable subject of the focus (provide to each interviewee a copy)

As wedidbefore ..withoutthinkingtoomuch… ..whatwordsoradjectives come toyourmind after thispresentation, be honestbecausewealsoneedcriticism, writethemeachofyouonyoursheet, fornowlet'slimitourselvestosinglewords….

Nowlet'stalkaboutittogether..whatcametoyourmind? (round table debate collectiononthebulletinboardofallthewords)…. Whythesethingscametoyourmind? Speakingfreely and widely ... What do youthinkaboutthis? Do younoticeanyflaws, shortcomings, in thisapproach, or in theseconclusions?What, instead, seems more correct and noteworthytoyou?

(get everyone involved. Encourage to evaluate each other'sideas)

3.1 LIST OF ENERGY EFFICIENCY INTERVENTIONS (5 min)

Take a look at table 1…. Considering the 3 sectors classification residential, industrial and commercial, what do you think about the list of energy efficiency measures… how would you define it?

Do you think that we forget something? Would you like to add some others? If so, which ones?

Why would you make these additions? What positive effects would we obtain by adding these other interventions?

(get everyone involved. Encourage to evaluate each other's ideas)

4. Qualitative analysis of the effects on the grid (15 min)

Presentation of Table A (give to each participant one copy)

6) Table A (*Qualitative analysis of the effects on the grid*), provides a summary analysis of the quality of the intervention, all technical aspects are considered jointly to leave room for the effect that the intervention has on the electricity grid. Table A contains 3 parameters for determining the class of evaluation: ***Energy, Conversion, Network.***

- ***Energy***: this value will be as high as the useful energy expected from the intervention, electricity is considered to have a higher value than thermal energy (values from 1 to 5). For residential sector we used following values for energy:

Readrapidly and individually Table A withoutcommentingoutloud

(leavetoeveryonetherequiredperiodof time toevaluatethe table individually)

CATEGORY	N	INTERVENTION	Energy
DISTRIBUTED GENERATION	1	Photovoltaics	4
	2	Wind	n.a.
	3	Solar collectors	3
	4	Cogeneration	3
	5	trigeneration	n.a.
STORAGE SYSTEMS	6	Batteries	3
	7	Hydroelectric	n.a.

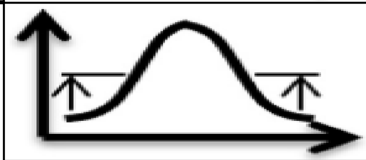
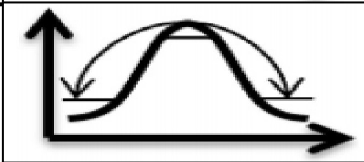
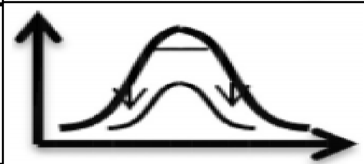
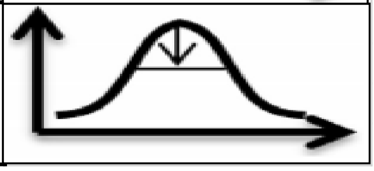
	8	**Compressed air**	**n.a.**
	9	**Hydrogen**	**n.a.**
	10	**Thermal storage**	**3**
	11	**Refrigerator storage**	**n.a.**
CONVERSION OF THE ENERGY CARRIER	12	**Heat pump**	**3**
	13	**Electric vehicles**	**n.a.**
BUILDING ENVELOPE	14	**Thermal coat**	**3**
	15	**Fixtures**	**3**
	16	**Solar screens**	**3**
THERMAL SYSTEMS	17	**District heating**	**4**
	18	**Heat recovery**	**n.a.**
	19	**Heat pump**	**2**
	20	**Speakers**	**2**
	21	**Hydronic appliances**	**3**
	22	**DHW recovery**	**3**
	23	**Circulators**	**2**
	24	**Fans**	**n.a.**
ELECTRICAL SYSTEMS	25	**LED**	**3**
	26	**Electric engines**	**n.a.**
	27	**Capacitor bank**	**n.a.**
	28	**Optimizers**	**3**
BUILDING and AUTOMATION CONTROL SYSTEMS	29	**Heating**	**2**
	30	**Domestic hot water**	**2**
	31	**Cooling**	**2**
	32	**Ventilation and Conditioning**	**3**
	33	**Lighting**	**3**
	34	**Solar screens**	**2**
	35	**TBM systems**	**2**

Now let's talk about it together.... What do you think of our evaluation? Do you agree with these values? ... Or would you propose others? If yes, for which ones do you agree? What are the reasons of these yours proposals? For which features do you agree with us and why?

(get everyone involved, entice to provide examples and explanations of their observations so as to evaluate each other's ideas)

4.2. Focusing attention on the network….the effects on the network are instead shown in the other figure

First of all look at the table individually.

Effect on the grid	Value	Graphical view
Strategic Load Grow	**0,7**	
Valley Filling	**0,8**	
Load Shifting	**1**	
Strategic Conservation	**1,2**	
Peak Clipping	**1,3**	

Network - the values associated to the grid effect

Now let's talk about it together.... What do you think of our evaluation? Do you agree with these values? ... Or would you propose others? If yes, for which ones do you agree? What are the reasons of these yours proposals? For which features do you agree with us and why?

(get everyone involved, entice to provide examples and explanations of their observations so as to evaluate each other's ideas)

5.1 Technical qualitative analysis with details of the benefits for the user (5 min)

For each parameters of Table B (Technical qualitative analysis with details of the benefits for the user), we associated a weight of 0.5 for COMFORT by user side.

Do you agree with this value? Why? Or do you think it would be more correct to increase it? Why?

(get everyone involved, entice to provide examples and explanations of their observations so as to evaluate each other's ideas)

6.1 TECHNICAL CHARACTERISTICS OF THE ELECTRIC STORAGE SYSTEM USED TO CLASSIFY THE RELATED ENERGY EFFICIENCY INTERVENTIONS (5 MINUTES)

In our work there are many technical characteristics of an electrical storage system that have been used to classify related energy efficiency interventions.

In particular, in your opinion, is it right to consider the useful energy of an accumulation equal to the energy that can be stored during the life of the system? What do you think of our evaluation? Why do you think this? Would you have made a different assessment? Different for which aspects .. could you give me an example of an alternative evaluation and why?

(get everyone involved, entice to provide examples and explanations of their observations so as to evaluate each other's ideas)

7.1 P4P SCHEME AND P4P RATES CONCEPT (10 min)

(provide to each interviewee a tag with this text)

Now I will read you a concept that is part of the evaluations of our work, each one of you has the same text so as to follow me better.

In SENSEI project, we use the concept of P4P scheme already applied in US. The P4P scheme brings with it the concept of P4P rates, that is currently being elaborated.

A P4P rate could be interpreted as a numerical value (€/kWh) that energy providers are willing to pay for each kWh saved or moved to another time of the day. These rates could vary according to the variations the electricity demand curve (a kWh saved at peak time is worth more than one saved at night / in the valleys).

The P4P these rates should have the ultimate aim of: avoiding network overload (too much electricity transported at peak times) and ensuring that the demand curve will be aligned with that of renewable energy production, in order to generate a return economic and 'environmental', allowing utilities to meet energy needs with the maximum percentage of economic and clean energy.

So let'stalkaboutthis…. What do youthinkofwhat I havejustreadtoyou? … ..How do youevaluatethis concept? ... Whatiswrongwithit? .... And whatiscorrect? .... Why do youevaluateitlikethis? …… Can youmakesomeexamples? What do youthink led ustoformulateitlikethis? Whatkindofreasoning led ustotheseconclusions?

Wrap up (5 min)

Thank you for your inputs.

Any final comments or questions?

We really appreciate you taking to time to participate in this research. And thank you for joining the sensei community now you can have access to our upcoming learning platform, *Engage Suite*, which will give you early mover advantage.

Incentive

By becoming a member, you will also receive our biannual newsletter, community news and publications, be invited to our events where you may showcase your expertise and discuss SENSEI’s latest progress and, if you wish so, have your company logo flagged alongside SENSEI activities all over Europe.